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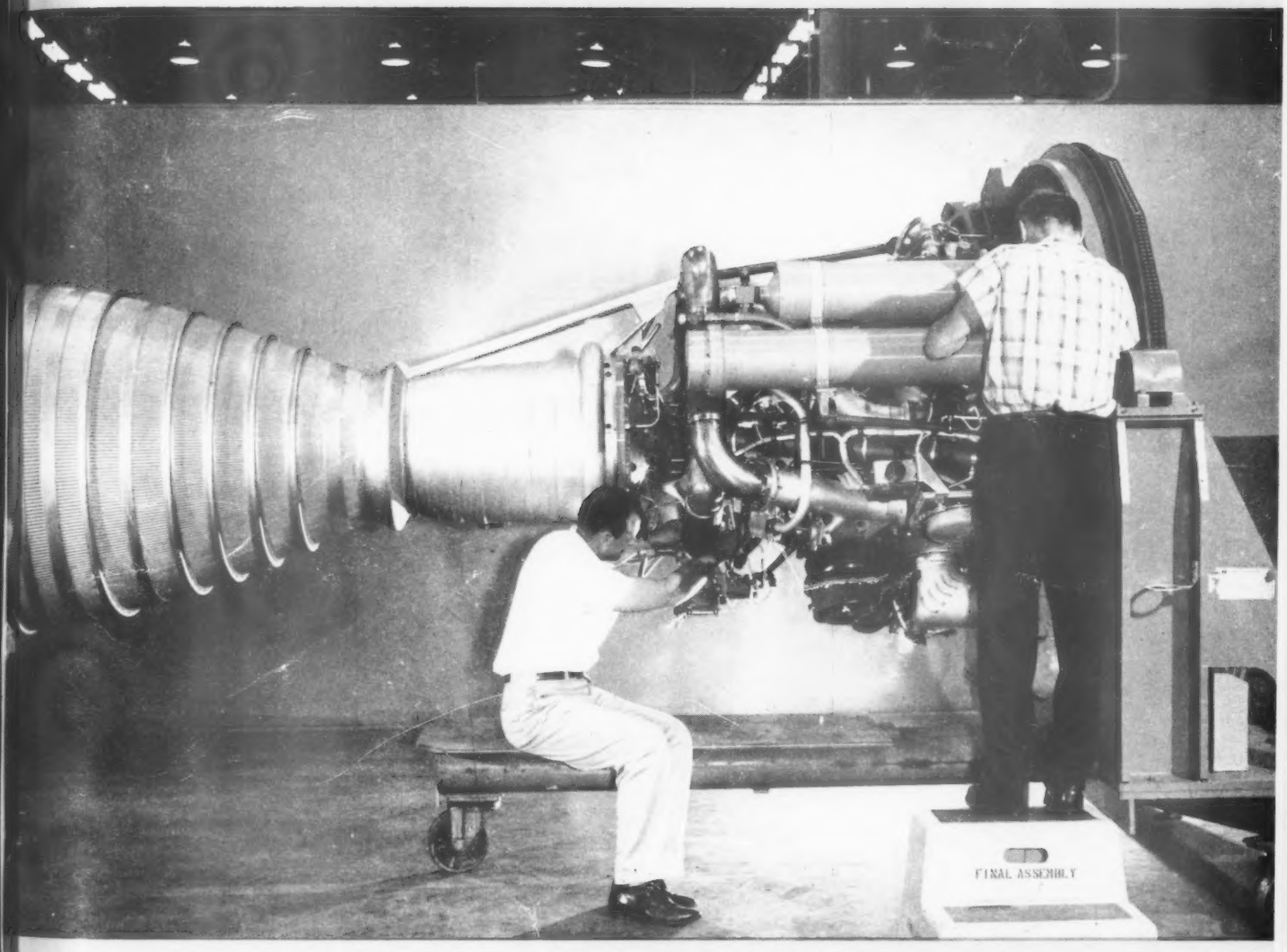

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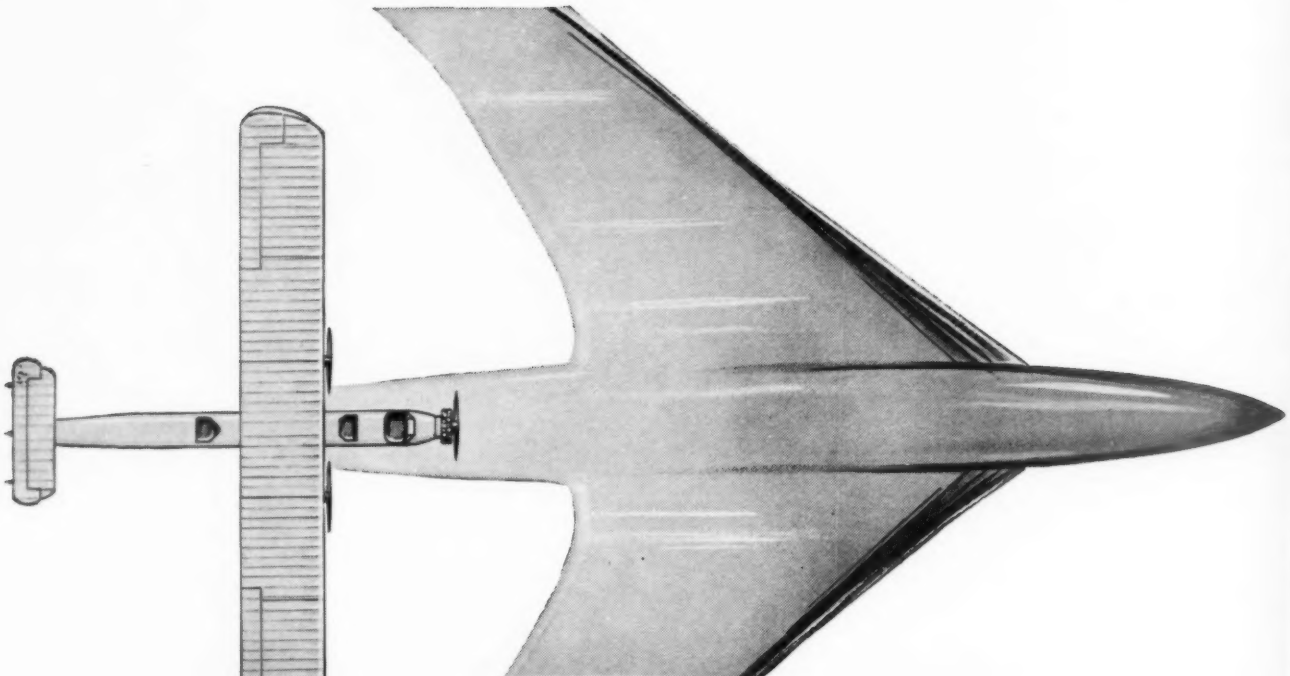
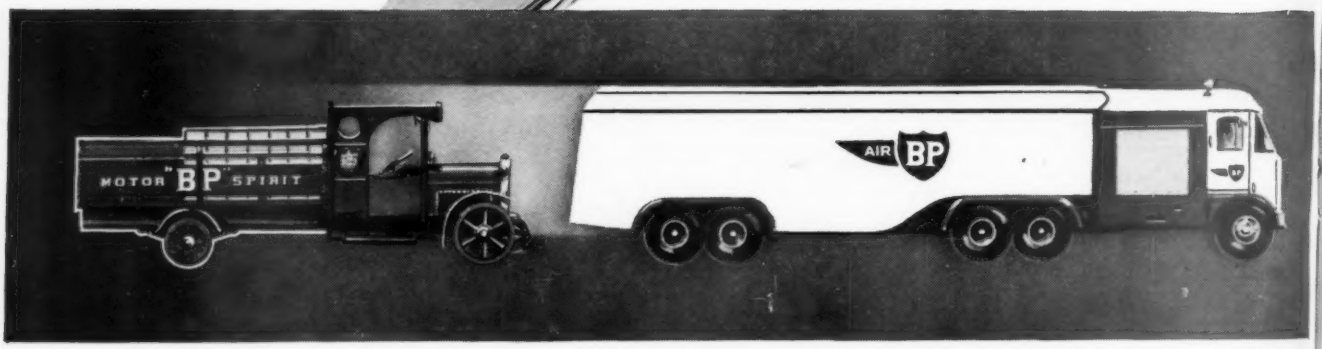


Keeping pace on the ground



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Spaceflight **is distributed to non-members in North America by** *Sky Publishing Corporation*, **Harvard College Observatory, Cambridge 38, Mass., U.S.A. All enquiries concerning subscriptions and single copies should be sent to** *Sky Publishing Corporation*. **A subscription for one year (4 issues) costs $2.50 in North America; two years (8 issues) $4.50; 3 years (12 issues) $6.00. Single copies at 75 cents each. Back numbers are available at these rates.**

PRINTED IN GREAT BRITAIN

Editorial

R. A. SMITH

It is with the greatest regret that we have to record the death of R. A. Smith, who died on 5 February 1959, after a long illness.

Ralph Smith was one of the leading pioneers of astronautics in Britain and a past-Chairman of our Society. In the nineteen-thirties, when the idea of space travel was still regarded as a joke, Smith was making forecasts which have since been translated into fact; he was also engaged in research work, and his contributions to the new science were of very great value. He was also known as one of the best of all astronautical-artists, and was the author of many scientific papers. In addition, he collaborated in producing several books.

We regret his passing as a great pioneer, and equally as a man, one of the best and most sincere friends. He will not be forgotten; his work lives on.

P. M.

SPACEFLIGHT: Change of Editorship

Patrick Moore, the first Editor of *Spaceflight*, has now retired from this post. He is succeeded by

K. W. GATLAND, 431a, Chertsey Road, Whitton, Middlesex,

to whom all editorial correspondence should now be sent. The Editorial Board is unchanged:

M. F. ALLWARD.
C. A. CROSS, M.A., F.R.A.S.
A. COLEMAN, M.A., F.R.G.S.
D. HURDEN, B.A., GRAD.I.MECH.E.
A. E. SLATER, M.A., M.R.C.S., L.R.C.P., F.R.MET.S., F.Z.S.

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Full particulars of membership of the British Interplanetary Society may be obtained from the Secretary. The secretarial address is 12 Bessborough Gardens, London, S.W.1; telephone TATe Gallery 9371.

NOTE BY THE FIRST EDITOR

So much has happened since we first produced *Spaceflight*, less than three years ago, that we seem almost to be living in a different age. What will happen by—say—1962 remains to be seen; but it will certainly be momentous.

Meanwhile the time has come for me to give up the post of Editor. I do so with great regrets, but in the knowledge that I am passing it into very competent hands indeed. With Kenneth Gatland in charge, I have no fears for the future of our periodical.

As a final word, I would like to give my most sincere thanks to all those who have helped me during my spell as Editor, and without whom my task would have been impossibly difficult: in particular to the Editorial Board, and to our contributors who have given up so much time to write for us. On the production side, I must thank the printers for their unfailing assistance, with a special word to J. W. Larman.

My best wishes for success in the coming years. I know that the future of *Spaceflight*, of the British Interplanetary Society, and indeed of all astronautics, will be bright.

PATRICK MOORE.

Towards a Commonwealth Space Agency

By KENNETH W. GATLAND, F.R.A.S. (Vice-Chairman)

On 27-28 August, at Church House, Westminster, the Society is holding a Commonwealth Spaceflight Symposium. This, the first meeting of its kind, may well be regarded as historic in its implications for the future of astronautics in this country and the Commonwealth at large.

The suggestion that such a meeting should take place originated during informal discussions by Commonwealth delegates attending the 9th Congress of the International Astronautical Federation in Amsterdam last year, when the following statement was issued:

Amsterdam, Wednesday, 27th August, 1958

"At the International Astronautical Federation Congress meeting in Amsterdam, it was decided today to set up a Commonwealth Astronautical Committee to assess the possibilities of Commonwealth countries engaging in joint activities in the field of astronautics.

"Immediately preceding the next I.A.F. Congress to be held in London in September, 1959,* it is proposed to convene a Special Commonwealth Symposium with the object of reviewing the possibilities of implementing such a policy. At this Symposium it is proposed to have strong scientific representation from the Commonwealth countries.

"The Committee is at present composed of representatives of four countries: Great Britain, Canada, The Union of South Africa, and India. Australia and other Commonwealth countries are expected to join later.

Commonwealth Astronautical Committee

The British Interplanetary Society, London, England.
The Canadian Astronautical Society, Toronto, Canada.
The South African Interplanetary Society, Johannesburg, South Africa.
The Indian Astronautical Society, Mysore State, South India."

The Commonwealth Astronautical Committee (C.A.C.) is inviting to this conference senior representatives of both Commonwealth government and industry, but there is certainly no intention of excluding smaller nations which lack a relevant technical background. At the present early formulative stage of astronautics, ideas are as important as technology, and we shall especially welcome participation of the universities and colleges. Symposium papers should have as a central theme the question of Commonwealth participation in space-research; examples of subjects relevant to this theme are listed below:

(1) What form should a Commonwealth Spaceflight Programme take?
(2) What special reserch activities would best be served by a joint programme (which do not conflict too heavily with work already being undertaken in Russia and the United States).
(3) Problems of organization and administration.
(4) Economic considerations.
(5) Industrial participation.
(6) Assessment of facilities.
(7) Rôle of universities.

Authors are being asked to submit manuscripts of their papers to B.I.S. headquarters by 1 June, 1959.

International Co-operation

During the past twelve months, increasing emphasis has been placed by the British Interplanetary Society on the need for some kind of collaborative programme in astronautical science. An official B.I.S. Press Release on 25th August, 1958, made the following comments: "The attainment of interplanetary flight has now become a matter of national prestige to two major world powers, Russia and the United States, where considerable resources are being devoted to the enterprise. The smaller nations are prevented by economic reasons from competing on anything like an equal footing with these large states. Unless future long-term scientific developments make the conquest of space less costly, the only hope existing for scientists and engineers of the many small nations to participate in this great new chapter of human history lies in collaboration. The British Interplanetary Society regards its future rôle in this light. The promotion of international co-operation in spaceflight, especially through the medium of the International Astronautical Federation, will be an important aspect of our policy."

The statement continued: "Today we are merely on the fringe of astronautics, and yet in Russia and America, work on satellites and space-probes already consumes a large amount of scientific manpower. Coupled with related work on ballistic missiles, this will represent a considerable drain on the scientific resources of the Great Powers in the years ahead—especially when the comparatively simple devices of today give way to projects for manned space-flight.

"The Russians have instituted vast programmes of technical education to fill the gap in this and other fields of science, and similar action must be taken by the West. A great deal, however, could be done by harnessing the scientific manpower of the smaller nations.

"Astronautics will undergo tremendous expansion in future years, far exceeding the economic and technical capabilities of any one nation. Co-operation is the *only* sensible solution; and if, for political reasons, this

* In fact, the I.A.F. Congress will be held in London (at the same venue) during the week commencing 31 August.

cannot be achieved on an international scale, we must seek the alternative of limited co-operation, always keeping in mind the ultimate objective of making astronautics a truly world enterprise.

"The British Interplanetary Society considers that, as a first step to active co-operation in astronautics, the United Kingdom and the Commonwealth should collaborate to set up a committee of forward-looking scientists to plan a British Commonwealth Spaceflight Programme. . . ."

A month earlier, on 14 July, 1958, the B.I.S. had issued a 2000 word statement drawing attention to the increasing pace at which astronautical science was developing abroad. "Already in satellite research," it said, "new and exciting possibilities are opening up in many branches of science and practical applications are 'just around the corner'. In the years to come, the knowledge and experience gained in this vital new sphere of exploration are likely to bring handsome dividends to the nations concerned. . . . The arguments which are being put forward range from the use of satellites for research in the field of nuclear physics (*i.e.*, satellite experiments related to cosmic ray studies, etc.) to the growing conviction that, before long, artificial satellites will have practical utility for weather observation, global reconnaissance, and as relay stations for television and F.M. radio.

"The question that remains unanswered is—how long can we afford to ignore space-research without seriously harming our scientific stature and without seriously impeding new avenues of research which will become increasingly vital to us in the future. . . . The gap between pure and applied science has been narrowed dangerously over the past few decades and, in order to maintain our progress, we must break out into space to find completely *new* fields of science. . . . Scientific research has never been amenable to rigorous cost accounting in advance. . . ." These were the salient points in the B.I.S. statement, which ended with these words: "If we have learned one lesson, it is that research and exploration have a remarkable way of paying off—quite apart from the fact that they demonstrate that man is alive and insatiably curious." These latter sentiments, borrowed from a report prepared by President Eisenhower's Science Advisory Committee, were linked with a five-point preliminary programme which the Society suggested, could be built up stage by stage by consenting nations of the Commonwealth as the necessary facilities become available.

Briefly, the programme envisaged (1) extension of the successful Skylark upper atmosphere research programme; (2) development of clustered and staged solid-rockets to carry research instruments beyond the 90 to 120 mile limit of the Skylark rockets; (3) adaptation of test-vehicles (*e.g.*, Black Knight) developed for research into warhead re-entry problems, to extend the range of scientific investigation; (4) adaptation of the de Havilland Propellers/Rolls Royce Blue Streak Long Range Ballistic Missile for the launching of artificial satellites heavier than the early Russian and American vehicles, using miniaturized components; and (5) investigation of the possibility of developing a rocket-powered research aircraft to obtain experience of manned flight on the fringe of space at several times the speed of sound. "In this country," it was pointed out, "there is already considerable experience in the development of aircraft rocket systems which, properly directed, might readily form the basis of a research programme into the problems of manned spaceflight. . . ."

These are examples of the type of contribution Britain and the Commonwealth could make to astronautics under a programme sponsored by a national agency, in the same way as the National Aeronautics and Space Administration has been charged with the task of carrying out space-research for the U.S. Government, and the Commission for Astronautics of the Soviet Academy of Sciences has been charged with similar work on behalf of the U.S.S.R. The B.I.S. statement continued: "There is growing experience with rockets, missiles and missile testing in Australia and Canada, and those Commonwealth countries which lack a background of relevant industrial experience could be brought into the scheme through the medium of their universities. This procedure has already proved itself in the work various university departments in the United Kingdom have done in planning experiments and providing instrumentation for the I.G.Y. rocket and balloon programmes. The scheme would contribute materially both to Commonwealth relations and to the prestige and influence of the British Commonwealth as a whole."

Commonwealth Facilities

The main argument for a co-operative space-programme is obvious: simply that several countries acting together would "spread the load" and place less strain—both technical and economic—on the resources of the parent nation. Indeed, the concensus of opinion among Commonwealth representatives with whom I have discussed the proposal is that we should not be making the best use of available resources unless the Commonwealth *was* brought into the picture.

Facilities that are immediately apparent are the growing rocket and missile centres in Canada, including the rocket launching site at Fort Churchill (used extensively for Aerobee and Nike-Cajun firings during the I.G.Y.); Australia's extensive rocket range based at Woomera, and the missile factories at Salisbury; the I.G.Y. tracking stations in South Africa.

Canadian Interest

The Canadian Astronautical Society, with headquarters in Ontario, has been especially active in promoting the idea of a Commonwealth Space-Programme and a phamphlet published by the group has received wide circulation.* After stating the view that "the

* See, for example, *Canadian Electronics Engineering*, November, 1958.

main propulsion stage (of earth-satellites and space-probes) could be the British Black Knight or the more powerful Blue Streak L.R.B.M. with upper staging employing solid propellant," the Canadian potential is examined in some detail. "On a speculative basis one can visualize the valuable developments of The Canadian Armament Research and Development Establishment in the solid propellant field as being directly applicable to the vehicle itself. Participation in systems management, communications, telemetering, tracking, data reduction and ground handling, are among the many areas in which Canadian industry and government laboratories are well qualified to be engaged, and the aircraft and electronics industries might well find themselves making significant contributions in any of these fields.

"Early activities in the Commonwealth space research programme would, of course, involve only a modest amount of activity in Canadian industry, but no doubt in the years ahead this would build up until a well-developed astronautic capability became established within the industrial complex of this country. Astronautics will certainly be big business in the future as it already is in the United States—the important thing is to make a start as soon as possible, no matter how humble.

"The Canadian aircraft industry, comprising manufacturers of aircraft and aircraft parts, together with associated electrical and electronic companies, is in a unique position to take part in a Commonwealth space programme.

"The industry has advanced scientific facilities and personnel, and proven achievements of design, development and production to lend support to this claim. These potentialities have not always been appreciated.

"The manufacturing facilities of the industry include more than 15 million sq. ft. of covered floor space, over one half of which is used for airframe manufacture and overhaul. The industry has fixed assets with a total replacement value of around $350 million, and gives direct employment to some 47,000 Canadians. Yet present programmes are only occupying about 50% of the industry's capacity.

"Ample facilities for research and development activities exist both in the industry and in associated government establishments, the industry and its associated companies alone employing some 7000 scientific and engineering personnel.

"The Canadian electronics industry is fully equipped and ready to serve in Canada's participation in a space programme. Components and end equipment to meet the environment of space are available from Canadian sources for such a project, while research and development facilities can be allocated for the solution of electronics space problems.

"There are over 25,000 workers directly engaged in Canada's electronics production, and there are well over 100 companies in the industry. Many of these companies are engaged in highly specialized component design and production, and are in a position to supply high-reliability components, equipment, and systems for space applications.

"The recording of satellite data, as well as their delivery from the satellite, is of course accomplished by electronic means, and the Canadian electronics industry is equipped to manufacture computers and instrumentation for these purposes.

"Indications are that production by the chemical and allied products industry in 1958 will be about 7% above the previous record value in 1957 of $1.2 billion. The business recession which started to affect the industry at the end of 1957, began to ease in the second quarter of 1958. Prospects point to this gain in production rate continuing in 1959.

"The chemistry and chemical engineering of explosives makes the field of chemical rockets an interesting one for the chemical industry and government research laboratories. Canadian chemists and chemical engineers are familiar with many of the problems involved, and industry either has the manufacturing facilities or could install them if necessary.

Materials involved would include the so-called conventional fuels such as hydrocarbons; chemicals for making liquid propellant systems such as hydrogen, lithium, hydrazine, ammonia, fuming nitric acid, hydrogen peroxide, ethylene oxide, fluorine; chemicals for solid propellants such as nitrocellulose, nitroglycerine, potassium perchlorate, and binders such as rubber, vinyl plastisols, polyurethane elastomers, polysulphides, polyesters, epoxy resins, etc.; nuclear propulsion too is a possibility for the long-term future."

South African Proposals

Tentative proposals offered by the South African Interplanetary Society include the use of Antarctic Territory as the Commonwealth satellite launching site for a Pole-to-Pole orbit. England, Australia and New Zealand between them have a claim to two-thirds of the whole area. The significance of a polar orbit is, of course, that research satellites will cover the entire globe, and from such vehicles reliable weather forcasting could be obtained.

"Geographically, the Union of South Africa is ideally situated between Australia and New Zealand on the one side and Great Britain and Canada on the other. Thus Cape Town would be the ideal supply base for the Antarctic launching site. Cape Town has already been an important base for the I.G.Y. expedition to the Antarctic.

South Africa already possesses well equipped observatories, tracking and camera stations. Established centres are at Cape Town, Bloemfontein, Johannesburg, Pretoria, Hartebeestpoort, and Elandsfontein where the U.S. Tracking Cameras are located. Later, the Society states, observatories in Southern and Northern Rhodesia could be used or new stations established to cover up to 2000 miles north of Cape Town."

[*Continued on page* 64.

A Philosophy of Astronautics?

By S. W. GREENWOOD

The British Interplanetary Society's programmes have been planned not only to assist the spread of technical knowledge, but also to bring home to the lay public the limitless possibilities of rocket propulsion, and in particular the ultimate implications to human society of the crossing of space. That statement, or something very much like it, appears regularly inside the back cover of the Society's Journal. The fact remains, however, that technical matters predominate and implications are rarely considered. One of the implications that is raised from time to time is the influence of astronautics and the successive achievements of space flight on human thought, beliefs, action and conduct. It is sometimes suggested that astronautics may be associated with a philosophy of its own. What is the prospect of this?

Astronautics

Ehricke[1] defines astronautics as the science of operating in space and travelling to other worlds. Many would consider that astronautics embraces also the art of doing these things.

Philosophy

My dictionary[2] defines philosophy as love of wisdom or knowledge, especially that which deals with ultimate reality, or with the most general causes and principles of things. The philosophy of astronautics that is usually considered appears to be a moral philosophy, defined in this dictionary as a study of principles of human action or conduct. It is to this aspect of the subject that this article will be confined.

A New Philosophy?

Two of the most energetic pleas for consideration of the case for evolving a philosophy of astronautics are those of Ross[3] and Ehricke.[1]

Ross says that astronauts have been far more concerned in rebutting technical criticism than in examining and countering criticism and misunderstandings of their practical philosophic aims. He makes the suggestion that there is a hope of philosophical and sociological salvation through the colonization of other worlds if we are prepared, first, and well in advance of technical adequacy, to make a thoroughly honest and completely objective study of human ends and means.

Ehricke says that the concept of space travel challenges man on practically all fronts of his physical and spiritual existence. He proposes establishing a broad perspective by formulating three fundamental laws of astronautics and examining their implications. The third of these laws is: "By expanding through the universe, man fulfils his destiny as an element of life, endowed with the power of reason and the wisdom of the moral law within himself."

The idea that our increasing knowledge of nature in this age of expansive activity calls for a re-examination of man's culture is made in a recent book by Gatland & Dempster.[4] They state that man has no alternative but to do this and learn to think again from the beginning.

In each of these proposals there is emphasis on the need for a new appraisal and this appears to be accompanied by an attitude that other and earlier philosophies have been restrictive or inadequate. It is perhaps necessary to note at this stage that this is my interpretation of what has been written, and it may be a rather unfair or imperfect interpretation. The subject is an involved one, and different people will ascribe quite different meanings to words and phrases that at first inspection might be supposed to be capable of only one interpretation.

Relation to Current Beliefs

Many writers have considered the influence of astronautics on thought and action, and while believing that this will be considerable, have felt that it is something that can be understood and interpreted within the broad framework of present beliefs and aspirations. To quote a single example, von Braun[5] believes that astronautics is in the forefront of a technological revolution which will eventually enable man to devote more time to think and to dream, and that it will raise our civilizations to levels never before attained. He expresses the view that there is a lack, not of "ethical legislation", but of day-to-day ethical guidance and control. He believes that for all our scientific enlightenment we know more mysteries to-day than when the technological revolution began. He says that religion and science belong together, and that there is a need for God to be "reinstated" in the heart of the world.

Opinions of the Author

Astronautics is primarily a science and an art. It may be compared with aeronautics, a science and an art whereby broadly similar problems have been tackled under less severe conditions for at least 50 years without resulting in a new philosophy. The prospect of a philosophy of astronautics emerging appears to be unlikely owing to the progressive development of aero-nautics into astronautics and to the divergence of beliefs among people engaged in it. There is a wide divergence

of opinion on the fundamental basis of nature, and in particular on the existence or non-existence of God. This divergence, which is the consequence of the impossibility of establishing the truth or otherwise of any basic assumption of this kind, operates to reduce the likelihood of the emergence of a distinctive moral philosophy acceptable to astronauts as a group. It seems more probable that a set of precepts will develop as a result of experience by which astronauts will find it practicable to be guided, but this is a different matter. Anything in the nature of an attempt at producing a philosophy will be an interesting manifestation of the character and personality of the persons responsible, but little else.

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Meteorites and the Origin of Life

By M. H. BRIGGS, B.SC., F.C.S., F.R.A.S.

Many of the enormous numbers of living creatures that once lived on Earth have left behind them after their deaths, clues which a trained biologist or geologist can interpret. These clues we call fossils and their study has the name of palaeontology.

Fossils can be of many different kinds. Animals and plants with hard calcareous shells leave their solid parts behind and after many years and billions and billions of deaths we are left with a solid white layer. Many of our famous landmarks, such as the white cliffs of Dover, were formed in this way and are simply huge piles of fossils.

Until fairly recently it was only possible to estimate the age of a fossil by what was nothing more than inspired guess-work. But with the dawn of the Atomic Age, radioactivity came to the rescue and gave us several excellent methods of dating not only any fossil, but also the rocks in which it is found.

These radioactivity methods have already been explained in many popular accounts and it would be pointless to repeat them here.[1] The close agreement between the ages of fossils determined by these new methods and the estimated ages from other biological and geological information shows that the methods are trustworthy and give accurate datings of old objects.

By using these methods it has been found that the oldest rocks yet tested are between three and four thousand million years old, whereas it is difficult to find fossils more than a few hundred million years old. This confirms something that both biologists and theologians have long speculated over; namely that life has not always existed on Earth.

We can now be fairly certain that the Earth was formed in some way about 4,000,000,000 years ago and then remained lifeless until comparatively recently. The exact date of the origin of life is not known and it is difficult to see how we can ever determine it exactly.

M. H. Briggs was educated at Manchester Grammar School and at the University of Liverpool. At present he is a science teacher at St. George's School of Montreal, and is Lecturer in Biology at the Thomas More Institute. He is in future to undertake biochemical research at the Cornell University, U.S.A.

But recent work indicates that we can put this interesting event approximately 800,000,000 years ago.[2] Sulphur is known to occur in two isotopes, S_{32}, and S_{34}. The ratio between these two isotopes in rocks older than this last date is 22·1 whereas in later rocks it increases slowly to 23·0. The ratio in the sulphates of the sea is 21·8. It is therefore clear that some process began to alter the sulphur isotope ratio about 800,000,000 years ago. This could only have been the sulphur oxidizing bacteria.

Aside from theological theories, two main proposals have been made to account for the origin of life on Earth. The first proposal, which has received much more support and thorough investigation than the

second, is that certain chemical processes occurred here on Earth and produced the complex substances of which all living tissues are composed, i.e., proteins, carbohydrates, etc. The suggestion continues by claiming that groups of these compounds adhered together giving them unusual properties, such as reproduction. From these primeval chemical agglutinations, life slowly developed and evolved.

The publications on this chemical theory of the origin of life are now very numerous and some of the proposed series of chemical reactions are very convincing. Nevertheless it must not be forgotten that they are all speculative and largely without experimental basis.[3]

The alternative proposal that has been made is that life began on Earth by the arrival of a living organism from somewhere else in space. This is an interesting speculation but has received little attention largely because it was difficult to see how any scientific investigation of the theory could be made. It also was objected to on the philosophical, but irrelevant, grounds that it did not account for the origin of life, it merely transposed the problem in space and time.

In view of contemporary knowledge it is interesting to reconsider the proposal. For example, there is a growing body of evidence for the existence of life on Mars.[4] This at once raises many problems to the origin of life.

If life begins as an accidental series of chemical reactions, then it is quite probable that there is only one possible combination of physicochemical conditions that will give rise to the right series of reactions. Now it is straining probability considerably to suggest that this same combination could have occurred on both Earth and Mars. But this of course assumes that Martian organisms are the same as terestial ones. We have very little evidence to assume that this is the case. Until we have actually submitted Martian life to biochemical analysis we will not be certain. On the few fragments of evidence that we possess there are similarities and differences. Let us consider these.

First, it is clear that there are patches of colour on the surface of Mars which slowly change with the season and melting of the icecap, in a way that resembles the seasonal change of earth vegetation. The observations of Tikhov[4] also indicate that these patches contain a pigment similar to that of certain of our plants (though not the usual forms of chlorophyll). It is obviously absurd to build anything on these slender facts, but they do indicate that the Martian vegetation is water dependent, capable of producing pigments and destroying them, and must consequently bear some resemblence biochemically to our organisms.

But we must remember at the same time that there is an obvious difference. All green earth plants undertake the complex series of reactions that we call photosynthesis. Basically this involves the convertion of water and carbon dioxide into large organic molecules which are used by the plant for food, etc. Photosynthesis, however, invariably produces free oxygen gas and here on Earth this process has undoubtedly played a large part in the formation of our atmosphere.

On any planet with photosynthetic plants on its surface, it is obvious that any carbon dioxide in its atmosphere will slowly be converted into oxygen. Consequently we would expect that Mars would possess free oxygen in its atmosphere. Unfortunately observations show quite clearly that it does not.

This evidence would indicate that Martian vegetation differs from that of Earth. But we must not be hasty in our judgment in view of our few observations. There are many other possible explanations of the lack of oxygen which would be compatible with Earth-like plants. For example, there may be some process occurring on Mars that absorbs oxygen as it is formed. Or life may be relatively new on the planet and not have had sufficient time to release enough oxygen for us to detect.

Unfortunately we must wait for future results. But we can deduce that if Martian plants prove to be chemically different from our own, then this points probably to a chemical theory of origin. However, if they are the same or very similar, we will tend to favour the alternative proposal. In which case the life forms of the two planets probably had a common origin. This may have been somewhere in the remote depths of space and twin "spores" fertilized each planet, or life may have originated chemically on either Earth or Mars and then have been carried somehow to the other.

The spore theory of life rests upon a number of assumptions which, although we cannot actually test experimentally, we can obtain a great deal of information about.

Basically the theory assumes that it is possible for life in some simple form to move through space and also to survive whilst so doing. It is possible to investigate both these assumptions in detail.

First let us consider the possible movement of spores. This problem was investigated many years ago by the great physical chemist Arrhenius[5] who suggested that tiny spores could drift up slowly through the atmosphere of a planet on which it originated. A certain percentage would actually escape from the planet altogether when a new force would take over and propel the spore. This is the minute pressure of sunlight.

Any body within several hundred million miles of the Sun will obviously receive light on one side only; the other will be in shadow. Provided that the body is very small then the pressure of the light will not be equal in all directions and it will slowly move away from the Sun. Consequently in this way spores could be being constantly released by any planet with life and be drifting away towards the outer planets.

If this concept of light driven spores should prove acceptable, then the movement could only be in one direction. In which case spores could not have arrived from another star system as it would have to enter the solar system against the pressure of light. Thus this would mean that life had originated within our planetary

system. It also means that life on Earth could not have come from an outer planet, such as Mars, as this, too, would mean a movement against the light pressure. Consequently the Arrhenius theory leads to the conclusion that life began either on an inner planet (which is very unlikely) or Earth, and then drifted to Mars.

But this slow movement by light is not the only way in which a spore might journey through the vastness of space. Assuming that spores could drift upwards in our atmosphere and eventually leave it, they could get caught by any body moving past them, such as a meteorite. It is well known that these small bodies are very numerous in space and differ in size considerably from very small to masses of several tons. With the advent of radio astronomy it has become clear that there are very many more of these swarms of rock and dust than was thought a few years ago. By tracking their orbits it has been found that many of them follow eccentric elliptical orbits around the Sun. When the orbits of a meteorite and the Earth cross a collison occurs and the meteorite plunges through our atmosphere. But it is obviously possible for the orbits to closely approach without crossing and in this case the meteorite will merely be deflected from its original course to continue its journey.

If we can admit the possibility of spores in the upper atmosphere then some must escape into space and be caught up with meteorites and carried off by them. This may be constantly happening to any life-bearing planet.

Due to the orbits of the meteorites it is quite possible for one to pass close to one planet and collect a spore and then to swing on and collide with a second planet. Should this ever happen and the spore survive its journey, it would develop; provided the conditions on the second planet were not too adverse.

Theory can consequently offer us two methods for a spore to cross interplanetary space, but it remains for experiment to determine whether they are practically possible. Let us examine the necessary deductions for each method and see how they bear up to empirical facts.

Both theories require small spores to be continually carried upwards from the planet's surface into its upper atmosphere. Theoretically there is no reason why winds should not do this, but fortunately there have been several studies of the biology of the upper air and these show quite clearly that many simple forms of life can be found at considerable heights. There are, for example, many different kinds of bacteria to be found anywhere up to about 500 metres and certain resistant forms can be found above 12,000 metres.[6] We can therefore reasonably conclude that some small organisms can and do get carried into the upper atmosphere and may leave our planet.

But once the spores have got into space we then must know if they are capable of surviving the conditions that we know to prevail there. Let us consider the main factors that will influence live spores.

In interplanetary space there is no air or water, both of which are necessary for life. Experiments show quite clearly that this will not be a handicap to encysted or resistant, resting spores. If a normal simple creature is suddenly exposed to a vacuum, it rapidly dies. But many organisms, particularly micro-organisms such as bacteria, form protective outermost layers when gradually exposed to unfavourable conditions. A spore slowly floating upwards would have plenty of time to protect itself in this way. The chemical processes inside such resistant organisms are found to be greatly slowed and they can consequently survive for long periods.[7]

It is probable that a suitable spore will be able to protect itself and adjust its chemistry so that it will not be killed by the lack of food and water in outer space. But space, of course, is not only chemically different from the organism's normal environment, it is also very different physically. The most obvious difference being that of pressure.

Space is almost a perfect vacuum and it is relatively simple to study the effects on small micro-organisms. The findings[8] show that provided the pressure is not released suddenly the resistant spores are unaffected. It is therefore demonstrated that certain types of organism can survive in the vacuum of space.

The next factor that is considerably different is temperature. It is possible to estimate the range of temperature that any spore would be exposed to. The temperature of any body in space that possesses no internal heat of its own is directly related to its distance from the Sun. The temperature at the surface of the Sun is in the region of 6,000° C. whilst the Sun's corona reaches about 1,000,000° C. From here on outwards the temperature falls off fairly rapidly until it approaches absolute zero, — 273° C. in the neighbourhood of the outermost planet, Pluto. Thus the temperature changes that a spore would experience would depend upon the planet from which it was released on the light-driven spore theory and the orbit of the meteorite on the other.

Experiments in the laboratory have established that many forms of life can survive temperatures up to about 150° C. and down to almost absolute zero. Several experimenters have shown that simple plants can survive immersion in liquid air for periods of weeks.[9]

We can therefore conclude that the temperature of space is not likely to cause the death of a resistant spore on either theory provided that if it is carried by meteorite it is not carried too near to the Sun.

There remains only one outstanding physical condition that we must consider; namely radiation. It is now well known that many types of radiation have fatal effects on all forms of living organisms if exposure is sufficiently prolonged and the intensity high enough. In space a spore would have to face two types of radiation in much larger doses than it would on the surface of a planet. These are the so-called "cosmic" radiation and ultra-violet light.

The nature of the former is still not completely known, but it would seem to be made up largely of common atoms, such as oxygen and hydrogen, from which the electrons have been stripped, moving at

terrific speeds. This radiation is continually beating down on the Earth from all directions, night and day. We are to some extent protected from it by our atmosphere for most of the radiation collides with the atoms of its gases. This produces an energetic "secondary" radiation in the form of broken fragments of these atoms. The secondary radiation is probably not as powerful nor as damaging to tissues as the primary.

Thus any spore in space would have to survive collision with these cosmic radiations. What effect this would have upon the spore we just do not know and there is almost no way of finding out except by direct experiment. The second Russian sputnik seems to have proved that quite complex living things can survive the impact of the primary radiation at least for a few weeks. If this is the case then there is every reason to believe that simple micro-organisms would be similarly unaffected.

A great deal of interest is now centred around the biological effects of radiation and much of it may be applicable to the problem of primary cosmic radiation on resistant bacterial spores. The main difficulty seems to be that we are as yet unable to produce radiation sufficiently energetic to exactly imitate the phenomenon. But by comparing some of the published results we are probably safe in concluding that the radiation is never completely fatal. Radiation always seems to affect only a small percentage of any collection of bacteria. It has also been calculated that only about 5 per cent. of the radiation hitting any particular micro-organism has any noticeable effect and even then not always a lethal one.[10]

It would be unwise to draw any definite conclusions until much more work has been done, nevertheless, at the moment it seems that spores in interplanetary space will not be entirely killed off by cosmic radiation. It is worth remembering that due to the enormous energy of the primary radiation, sufficient to penetrate over 10 ft. of lead, spores on or in meteorites are not protected any more than spores floating free in space.

The other main form of radiation that might prove hazardous to our spores is ultra-violet light. This can be much more readily investigated.

Our Sun is the main source of this radiation and is constantly pouring out very large amounts. Most of this, however, is absorbed by the gases of planetary atmospheres so that only a very small percentage actually reaches the surface. Here on Earth these small amounts of ultra-violet radiation are eagerly sought after by human sun worshippers as they have very beneficial properties, such as the production of vitamin D in the skin. But as anyone who has suffered from severe sunburn knows, excess radiation can produce very undesirable effects. In fact it is found that overdoses of ultra-violet radiation are lethal to almost all forms of life.

It would thus seem impossible for a spore to survive in outer space. But we cannot be certain of this as certain species of bacteria, for example, are very resistant to ultra-violet radiation, particularly in their spore forms. The previously mentioned bacteria discovered in the upper atmosphere are all of the resistant type. Even amongst a resistant species the actual resistance to radiation of any particular organism probably varies within perhaps quite wide limits. The distribution of many other bacterial characteristics follows this statistical distribution, and it is reasonable to conclude that certain organisms will be very resistant.[11]

If we assume that this is the case, then these special individuals will have an excellent chance of surviving whilst they are carried into space in the manner that we discussed earlier. Once here their survival will depend upon the amount of time they are exposed to the Sun's radiation. For this reason it is unlikely that spores could float around free for long periods as the light-driven spore theory requires.

But let us consider the other alternative, a spore caught on, or in a meteorite. Ultra-violet radiation is not very penetrating and can be completely stopped by a small thickness of solid material. There is therefore every reason to believe that a spore carried in this way might well survive this type of radiation.

By considering the known conditions of outer space and comparing them with what is known about the conditions required for the survival of the spores of micro-organisms, we see that there is little objection to the theory that metorites might pick up a spore in a close approach to a planet and then carry it to a second. There remains, however, one further objection.

Let us admit that a spore can be carried out of the atmosphere, caught by a meteorite and carried to a second planet. There remains the actual arrival to the surface. Meteorites travel with different velocities and their velocity of descent through a planetary atmosphere will depend upon many factors, but will almost always be sufficient for the friction between the meteorite and the gases of the atmosphere to generate a considerable amount of heat. In our own atmosphere small bodies from outer space generate enough heat on arrival to become incandescent (shooting stars) and the great majority never reach the surface as they are completely burned up. It would therefore seem unlikely that a spore could survive the passage through the atmosphere.

But before we try to reach any final conclusions let us consider the meteorites that have actually been collected from all over the world. They are of three main types, iron, stone and tektites. The first are composed of about 90 per cent. iron and 8 per cent. nickel. The second, which are the commonest, are small pieces of stone made up of elements in proportions similar to the Earth's crust. Certain meteorites are intermediate between these two types and are known as the stony-irons. The last class are very rare and are made up of silica, a glass-like substance.

If we examine the surfaces of the two main kinds of meteorites we notice that there is some difference between them. The iron meteorites are often jagged, but with relatively smooth faces, the stony types, on the other hand, are very porous and uneven with typically rough faces. There is consequently little visible evidence on the actual meteorites to show that they

have suffered from extreme temperatures. It is not known with certainty what temperatures are produced by the arrival of these objects into our atmosphere, but it is fairly obvious that the temperatures will be highest on the outer surfaces. The temperatures of the interior will depend upon the thermal conductivity and dimensions of the meteorite. Metals are good conductors of heat and we would expect their interiors to become quite hot, but stone is a bad conductor of heat and the interior might well remain relatively cool.

When we combine this deduction with the observed porous nature of the stony meteorites, then we cannot be certain that a spore inside such a body would be killed on arrival. In view of our inadequate knowledge the problem will only be settled by future observations, but at the moment we can say that here is a good probability that our spores would survive.

Thus we are left with only one other objection, that the heat produced by the actual impact with the Earth's surface would be fatal. But as we have seen there is a lack of evidence to show that the interior of a stony meteorite would rise to a high enough temperature. In the case of the Earth we can also see that with such a large amount of water-covered surface, meteorites with spores striking an ocean would not heat up very much.

We have so far attempted to show that although there are reasons why free spores could probably not survive for a long enough period to cross interplanetary space, there is a lack of evidence to show that a spore trapped inside a stony meteorite could not survive both an interplanetary journey and an arrival on a planetary surface.

The two theories of the origin of life on Earth can neither be conclusively proved, but the spore theory allows us to make a prediction which is testable by observation, which would considerably strengthen it. If spores are carried by stony meteorites then we should be able to detect them by opening such a meteorite and conducting a micro-biological survey and analysis. Due probably to the *a priori* unlikely nature of this test, and also of the difficulty of obtaining meteorites and taking the necessary sterile precautions, the experiment has not been favourably viewed by bacteriologists. Nevertheless a search of the literature has revealed one such test that was carried out some time ago.[12]

As far as can be judged by the author's descriptions of his experiments his precautions were reliably carried out. His results are very interesting for he detected the presence of several different species of bacteria. It would have built up the case for the spore-theory if these had been new and previously unknown varieties of organisms, but unfortunately they were very common terrestial species. This, however, does not disprove or tell against the theory, but it does allow the suspicion that the bacteria detected had arisen by some undetected contamination of the material. Yet if spores of bacteria are constantly arriving from outer space it is to be expected that terrestial bacteria will resemble them for they are their descendants.

We cannot let the matter rest here for it is very important that we try to decide which of our alternative theories of the origin of life is the most likely. Should the spore theory be proved correct we will have to establish a new branch of biology. Yet recent developments in other sciences have indicated the best method for gaining new evidence. If meteorites can be collected before they strike our atmosphere, in suitable sterile conditions, then they can be examined and should any organisms be detected we will then be certain that they are not contaminants.

Obviously the best method of doing this would be to establish a bacteriological laboratory in outer space, but there is little likelihood of this happening for many years yet. But there is a second alternative that might serve the same purpose.

With the establishment of artificial satellites, much research seems to be centred around the problem of bringing a satellite safely back to Earth for examination. There is little doubt that recoverable satellites will soon be a reality. Provided that the physicists and the astronomers will allow a little space for biological problems, the establishment of a small satellite for trapping meteorites would not be too big a problem. Such a vehicle would be essentially a hollow cylinder with automatically opening panels. Inside would be a thick layer of sterile gelatine or agar into which small bodies would embed themselves. After orbiting for a long enough period and collecting a number of meteoric bodies the satellite would be returned to Earth for examination. The main problem would then be ensuring a sufficiently sterile examination throughout all stages of dispatch and return.

The discovery of spores in meteorites in this way would strongly support the theory that life began on Earth by the arrival of such a meteorite, but it would not prove it. It would also indicate that life on Mars is of a similar type to terrestial life. It might also explain the lack of oxygen in the Martian atmosphere, for life on Mars may have begun by the arrival of a terrestial spore only a relatively short time ago. But it might also mean that life on Earth was a different variety of a basic form which began on Mars. It will remain for future research actually in space and on the Martian surface to solve problems such as these. If it should turn out that Martian life preceded life on Earth, then we might well be an offspring from the other planet. Every time we look into a mirror we may be seeing a Martian.

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That New Planet

"As for the Sun's new satellite, I cannot help wondering who on Earth now owns it. My expert adviser on space technology and law, Sir Justin Galaxy, said to me last week with cosmic humility 'I don't know'.

"I imagine the matter will not go before the courts until, in 300 years' time, the Society of Space Antiquarians charters a Scruggs S.A. 423 Spacematic for a week-end space archaeology outing to locate it. With a good driver, Interstella Decca Mk. 10, plenty of knitting patterns for the old ladies, and a bit of luck, they could draw up alongside the thing, chuck out a tow-rope and bring it back for M.o.S. experts to examine. Then, armed with its secrets, Britain could Catch Up In The Space Race".—"Roger Bacon" in *Flight*.

"Those who were sure that the Russians did aim their 'probe' rocket at the Moon are supported by the implication of a cable sent to Washington from Moscow. It goes: 'ANYTHING YOU CAN'T DO WE CAN'T DO BETTER'."—"Wren" in *The Aeroplane*.

"In view of the great expense and difficulty involved in firing rockets at the moon, I suggest that future attempts should be made when the moon is full. There would be a better chance of hitting this larger target than hitting the thin crescent present at the time of the latest Russian attempt".—Letter in the *Glasgow Herald* (quoted in *New Statesman*).

Not Really Important

By "URSUS"

In my constant search for some of the less publicized aspects of astronautical science, I have recently come across one or two reports which should, I feel, be placed on record. Particularly interesting is the case of Mr. Arliss French, of Appleton, Wis. Apparently an American cosmetics firm promised a free trip to Mars to anyone who collected nine hundred empty tubes of the appropriate shaving soap. This seemed to be a fairly safe bet, but like many other "dead certs" it went wrong, as Mr. French successfully gathered in the full complement of tubes. One imagines that the immediate result was one of panic in the firm's offices, since neither Cape Canaveral nor Moscow is yet in a position to provide tours to Mars, and the alternative—admitting defeat—was obviously unthinkable. Fortunately, it transpired that there is a village called Mars (pop. 78) near Wesel, in Germany, and this seemed to satisfy the conditions of the agreement. Mr. French proceeded there at the firm's expense, travelling not by space-ship but by aeroplane and train, and added to the gaiety of the proceedings by distributing free tubes of shaving soap to members of the public who watched him leave. Honour was thus preserved, and yet another scientific expedition came to a happy end.

It must be added that the American Department of the Interior has made it clear that "it is not now nor has it ever been possible for anyone to make application for or obtain the right to land on the Moon or planets through the United States Government". Since lunar plots (including all fishing rights) have been widely distributed by various unofficial land agencies, it is just as well to make the whole position clear.

In any case, the enthusiasm of the faint-hearted may easily be killed by a suggestion made by Dr. Robert Tischer, of Mississippi, that future space-crews may have to get used to a diet of slugs or snails. For a long flight it is true that algæ for breakfast, lunch, tea and dinner would become rather monotonous, but creatures such as snails and slugs can themselves exist quite well upon algæ, and the inference is plain. Whether the catering officials at rocket proving grounds can bring themselves to serve up poached snail or slugs on toast must, however, be considered doubtful in our present stage of technical development. Undoubtedly this is yet another instance in which Man will have to learn to adapt himself to the rigours of Outer Space.

Space and the Universe—The Beginnings

From Sputnik, Pioneer and Lunik—To an Amazing Future

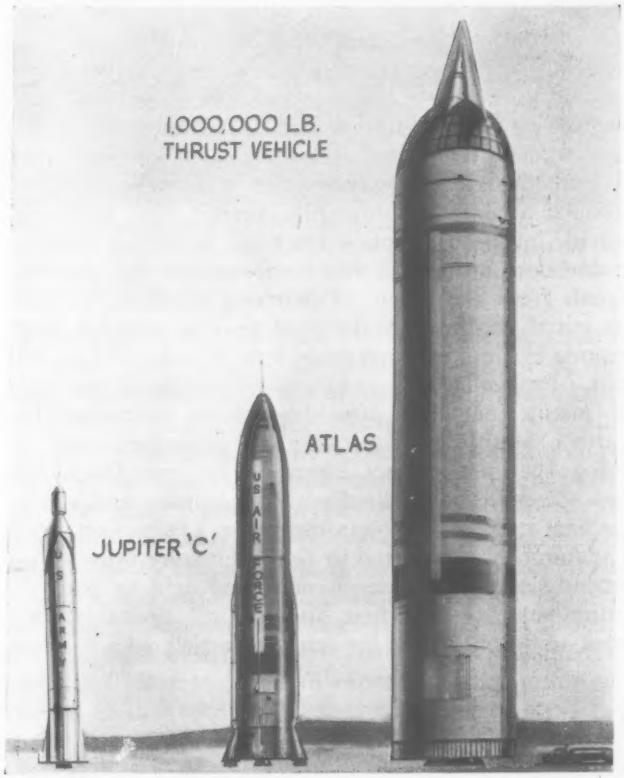
By FRANK B. POLLARD

Astronomers, physicists and chemists of the past have made great scientific discoveries and established the solid base from which our scientists and engineers of the present work. In our turbulent times, we are setting a new pace in opening the door to the universe. It has been true, historically, that the scientific advances in *hardware* have been made mainly during periods of war and, seemingly, are functions of such strife. New and basic foundations in the science of rocketry are being established today—and these too are only beginnings. Countries and peoples who have not been recently active in the rocket field are now planning ventures which may prove to be extremely successful and startling.

There have been many rocket firings and space experiments since the first Sputnik went into orbit on 4 October, 1957. The successes, recorded here, represent an impressive step in our collection of scientific data.

From these experiments much knowledge has been gained: the vehicles and their systems have been proven; tracking facilities have been proven; space-borne instrumentation has been tested; materials research has been accomplished; magnetic fields have been explored; measurements of temperatures and densities in the upper atmosphere and space have been made; micrometeorite impact detection, cosmic ray intensity, radiation intensity, satellite environmental conditions (measurement of temperatures and pressures internal and external) and a great deal of other detailed data have been compiled. Research rockets such as the Aerobee have been regularly fired and data from these firings have been added to the enormous amount of information being analysed to aid the success of future attempts. But where are we going and what can we look forward to in the next year or two?

In 1959, at the Pacific Missile Range at Vandenberg A.F.B., California, a series of at least a dozen satellite firings, approximately one a month, are scheduled. Called Project Discoverer, the purpose of these firings will be to develop new systems and techniques to be employed in the future operation of manned space vehicles. Initial firings will test the vehicle, its propulsion and guidance systems and the tracking and recovery systems. Follow-up firings will consist of vehicles containing biomedical specimens from which we can obtain data on the environmental conditions man will be exposed to in his flights into space. Plans call for a two-stage system utilizing a modified Thor first stage and a Bell Hustler second-stage. Payload in orbit is



1,000,000 thrust engines will be tested late this year. Drawing shows the relative size of a missile that can be launched as compared to the Jupiter "C" and Atlas configurations now being used

expected to be in the neighbourhood of 1300 lb. (including the weight of the second-stage which will orbit as an integral part of the payload).* It has been stated that the first nine attempts will be made with the Thor configuration and that the remainder of the firings will use an Atlas first-stage and a Bell high-energy liquid propellant second-stage. Magnesium, in a new high strength-to-weight ratio alloy, will make up the skin of the vehicle's second-stage and was selected to resist the high aerodynamic heating and the wide temperature variations as the vehicle passes in and out of the sun's illumination.

Vandenberg A.F.B. is situated in an excellent geographical location to launch vehicles approximately due south and to place satellites in a polar orbit without endangering inhabitants in close proximity to a southerly

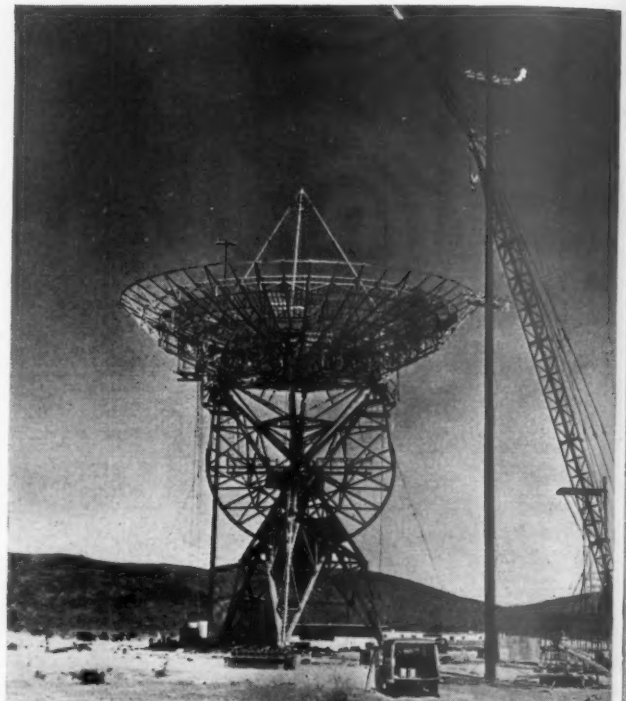
* The initial launching was, in fact, made on Feb. 28, as we go to Press (*see table, p. 47*). Ed.

launching path. Until these firings take place, we will never have placed a satellite in a true polar orbit. The advantages of an orbit such as this are many. A satellite in polar orbit could scan large areas of the Earth in an extremely short time; the variations in the Earth's magnetic field could be studied with great accuracy and detailed data on the variation and intensity of cosmic radiation entering the Earth's atmosphere could be obtained. With several satellites in a polar orbit simultaneously (staggered at proper time intervals) the Earth could be scanned on a 24-hour basis and would provide not only military data but might trace the behaviour of air masses over remote areas of land and sea. Storms, as they form, could be monitored and tracked on an hour-to-hour basis and solar radiation, heat circulation and heat transfer studied as it is related to meteorology. Instrumentation is now available to produce accurate photographs, permit T.V. scanning, provide infra-red detection when the satellite is orbiting in darkness, store data and communicate that data on signals from the Earth. Discoverer satellites, at least the initial versions, are designed to orbit only for short periods of time at a relatively low altitude (175 to 200 mi.). Project Discoverer firings will include the recovery of missile payloads after they have re-entered the Earth's atmosphere—recovery of instrumentation or living specimens *intact*. NOTE: The first Discoverer was scheduled to be fired early in January and was in the final stage of the countdown when a failure occurred. The failure was reported to be a premature firing of the second-stage engine which permitted acid to foul the entire vehicle. The first attempt will probably have been accomplished by the time this article goes to press.

The X-15

The X-15 project is now under way and is another necessary programme in man's step into space. The primary purpose of this vehicle is to gain knowledge of flight conditions beyond the Earth's atmosphere, obtain aerodynamic heating data and measure the effects of this heat on the vehicle's structure and components. In addition, the first accurate study of control, exit and re-entry problems will be made. Reliable studies of man's reaction to weightlessness, acceleration and deceleration will be delved into as well as cockpit environment, hazards, systems and the psychophysiological aspects of human flight in space.

Due to the high temperatures expected on the X-15 during flight (a range from 1200° F. to minus 300° F.) Inconel X was selected as the material of primary construction. The welded external armour of Inconel X will cover a structure made up of titanium and stainless steel—and aluminium where heat and high loads are not considered critical. Eight major systems are built into this missile: the engine, propellant system, hydraulic system, primary flight control system, auxiliary power units, ballistic control rockets, landing gear and air conditioning and pressurization systems.



Goldstone Tracking Station has an 85-foot-diameter antenna built on the California desert by the Jet Propulsion Laboratory (CALTEC) to track and receive telemetry from American moon-probes

Capable of over 50,000 lb. thrust, the X-15 will use the XLR-99 engine utilizing liquid oxygen and anhydrous ammonia (the weight of the fuel is 15,000 lb., almost half the total weight of the vehicle—31,200 lb.). Two hydraulic systems in parallel will power the horizontal and vertical tail control surfaces, the speed brakes and the landing flaps. At extreme altitudes (beyond the Earth's atmosphere) control of the X-15 will depend on hydrogen peroxide thrust units or ballistic control rockets, located in the nose and wingtips of the vehicle. The pitch and yaw of the missile will be controlled by the nose jets and the roll by the wingtip units. A dual nose wheel and landing skid combination, both manually retractable, will be used for the high speed landings necessary. The pilot and instrumentation will be pressurized and air conditioned by a liquid nitrogen system and with the aid of new and unique insulating materials.

Initial drop tests are now under way at Edwards Air Force Base with the X-15 being dropped from a B-52 bomber. In actual operation the X-15 will be dropped from the mother ship at 38,000 to 40,000 ft. and, at launch, the pilot will fire the rocket engine. In approximately 90 seconds, the fuel will be exhausted and the X-15 will coast up to the 100 mile altitude. Speeds in excess of 4000 miles per hour are expected and the tricky art of controlled re-entry will be studied by man in the cockpit of a missile. And while the man in the

cockpit studies re-entry, he himself will be studied by means of delicate instrumentation which will record his physical and mental reactions.

Project Mercury

The selection of a United States citizen to make the first manned orbital flight will be made this year. The design, development and construction contract for the Project Mercury space capsule has been awarded to McDonnel Aircraft Corporation. This capsule will be the payload of a powerful and as yet undisclosed booster vehicle which will enable a man to leave the atmosphere orbit around the Earth and safely return. Men selected will undergo rigorous environmental programmes, for example, in centrifuges that simulate the high accelerations and decelerations encountered during exit and re-entry. Balloon flights to very high altitudes in Project Mercury space capsules will provide additional environmental conditioning. Initially, short range, solid fuel boosters will launch Project Mercury mockup capsules into sub-orbital trajectories and then successively longer range flights will be made. Animals will be launched in the capsule and finally man—and through his flights, research in the psychological and physiological effects on man will be explored in great detail.

Space Probes

In addition to the Project Discoverer series, at least a dozen space probe or satellite launchings are planned for 1959. Payloads will travel in the vicinity of the moon and perhaps impact on its surface. Instrumentation will scan its surface and give us a good "visual" study of its unseen side.

Probes that will travel in the vicinity of Mars, Venus and beyond could conceivably be fired this year. June, 1959, is the optimum time to launch a vehicle in the direction of Venus, and late 1960, optimum for a probe to Mars. The vehicles planned for use will be the Atlas, Thor-Able, Juno II and Vanguard. These units are now reliable and becoming increasingly more so with each successive firing. Basic research in propulsion now going on will provide 1,000,000 lb. thrust engines in the next few years. Thrust of this dimension will enable us to place extremely large payloads in orbit and we may have the much talked about space stations from which innumerable experiments can be made. Nuclear engines, ion rockets, thermonuclear engines and plasma propulsion are only a step away. The picture presented is bright and clear and we can expect amazing results in the next 15 to 30 years.

Atlas Propulsion System. The primary units are composed of a twin-chambered booster at left and right, a sustainer in the center and two small vernier, or stabilizing engines, mounted on the missile frame to prevent roll

	Launched	Wt.-lb.	Size	Payload	Lifetime	Apogee (Mi.)	Perigee (Mi.)
SPUTNIK I	4 Oct, 1957	185 lb.	22·8 in. dia.	Instruments	3 months	560	145
SPUTNIK II	3 Nov., 1957	1120 lb.	70 ft. long	Instruments and dog	6 months	1056	150
EXPLORER I	31 Jan, 1958	30·8 lb.	80 in. long 6 in. dia.	Instruments	2–5 years	1600	220
VANGUARD I	17 Mar., 1958	3·25 lb.	6·4 in. dia.	Solar batteries and radio	2000 years plus	2513	407
EXPLORER III ..	26 Mar., 1958	31 lb.	80 in. long 6 in. dia.	Instruments	3 months	1735	125
SPUTNIK III	15 May, 1958	2919 lb.	11 ft. 8 in. long 5 ft. 8 in. base dia.	Instruments and solar batteries	19 months	1168	150
EXPLORER IV	26 July, 1958	38·43 lb.	80 in. long 6 in. dia.	Instruments	13 months	1700	180
PIONEER I	11 Oct., 1958	83·8 lb.	29 in. dia.	Instruments	47 hours	Maximum altitude approx. 79,000 mi.	
PIONEER III	6 Dec., 1958	13 lb.	23 in. × 10 in. dia.	Instruments	38·6 hours	Maximum altitude approx. 66,654 mi.	
PROJECT SCORE (ATLAS) ..	18 Dec., 1958	8750 lb. 168 lb. payload	Atlas minus booster	Communications	1 month	650	125
LUNIK	2 Jan., 1959	3240 lb.		Instruments	Indefinitely	Solar orbit— Perihelion 91,000,000 mi. Apihelion 122,500,000 mi.	
VANGUARD II	17 Feb., 1959	21·5 lb.	20 in.	Weather Reconn.	200 years plus	2050	335
DISCOVERER	28 Feb., 1959	1300 lb. 40 lb. payload	18·8 ft. × 5 ft.	Instruments	3–4 months	519	176
PIONEER IV	3 Mar., 1959	13 lb.	23 in. × 10 in. dia.	Instruments	Indefinitely	Solar orbit	

News Diary

By PETER BAILEY

November, 1958

The space race was in full career in the last two months of 1958, although at the time the only two contestants appeared to be the U.S. Army and the U.S. Air Force. The U.S.A.F. at present handles the bulk of U.S. rocket development, but this has not always been so. The Army was first in the field, and made considerable advances until the Wilson Memorandum of November, 1957, forbade them to develop or operate any weapon with a range of more than 200 miles. This decision caused much hard feeling at the time.

In November, after the third and last U.S.A.F. moon shot had failed, it was the Army's turn, and they sounded pretty confident. The U.S.A.F. on the other hand seemed jittery, and released snippets of information almost daily.

On 16th November, for instance, they revealed that a mysterious ball found floating off Barbados in October came from the Atlas rocket which flew a 2500-mile mission from Cape Canaveral on 2 August. Radio messages from rockets were interrupted soon after re-entry by heat- and pressure-ionization of the air round the nose-cone. Consequently, instrument readings during this period were tape-recorded and stored in 18-in. dia. balls. The ball in question had drifted ten weeks before being picked up by fishermen, yet 85% of its taped data was still readable.

Professor A. C. B. Lovell, Manchester's Professor of Radio Astronomy, said in his second Reith Lecture on the B.B.C. on 16 November: "We are now moving headlong towards a solution of the problem [of the origin of life]. Direct contact between some form of space vehicle and the Moon, and also planetary atmospheres must be close at hand." Data sent back by these probes might explain how the large complex molecules characteristic of life came to be formed. But care must be taken to ensure that the probes did not carry Earth-developed macro-molecules with them to other planets and thus prejudice future explorations.

Addressing the American Rocket Society in New York on 19 November, Miss Van Der Wal said that America's highest flying mammals were white mice. This spring and summer three mice had gone 1400 miles high in Thor-Able rockets fired by the U.S. Air Force. One at least had certainly survived re-entry into atmosphere and made a parachute descent into the South Atlantic, but ships which should have picked it up failed to locate it.

Space and oceanic research were discussed by the final session of the N.A.T.O. parliamentarian's conference in Paris, and Senator Jackson, chairman of the Scientific and Technical Committee, told a press conference on 21 November, that a N.A.T.O. satellite could be in orbit by 1960. Dr. von Karman, chairman of the Advisory Group for Aeronautical Research and Development, said he was getting together a committee for studying the project. The satellite would be exclusively for peaceful purposes.

The wrangle in the United Nations Organization as to who can make most propaganda out of the peaceful uses of space vehicles ended in deadlock on 24 November. Mr. Cabot Lodge announced that he had failed to reach agreement with the Russians in private talks. "We hope the Soviet Union will co-operate," said Mr. Lodge. "If . . . not . . . I do not think that is reason to falter. We can still do useful work." The political committee of the General Assembly then approved by 54 votes to 9 the Western proposal for an eighteen-nation committee to study the question and report back to the next General Assembly. "Well, sir, you have got your majority in your pocket," testily commented Mr. Zorin, Soviet Deputy Foreign Minister; he did not put to the vote the rival Soviet plan for an eleven-nation committee to draft rules and programme for a permanent international space research agency. Both Russia and Czechoslovakia declined to take part in the proposed eighteen-nation committee.

Laporte Chemicals opened at Warrington on 25 November a new rocket fuel plant. Built in two years at a cost of £2½ million, the works will double the firm's output of high test hydrogen peroxide, and should make lower prices possible. 85-90% H.T.P. is the oxidant in many liquid fuel rockets, including the 19,000-lb. thrust four-barrel version of the Armstrong Siddeley Gamma, which powered the Black Knight, British research rocket recently tested at Woomera.

According to an announcement on 26 November, the U.S.A. will launch in 1959 at least a dozen, probably a score, of space-vehicles of various kinds. High priority is being given to work on the Venus probe, a weather satellite orbiting over the poles is planned, and the U.S. Air Force plan to launch several military reconnaissance satellites.

The fifteenth Atlas inter-continental rocket to be tested at Cape Canaveral roared off its launching pad on Friday, 28 November. Some 30 min. later the nose cone arrived off Ascension Island, and although not actually recovered it is believed to have fallen within 30 miles of the target.

Atlas stands 85 ft. high and weighs about 100 tons at take-off. Burning the U.S.A.F. standard liquid oxygen and RP-1 mixture, its three engines all fire together, giving a 400,000 lb. initial thrust. The two booster engines drop out after a period, leaving the sustainer engine to accelerate the missile to its 15,000 m.p.h. top speed. Atlas has been under development since 1946, although nothing much happened in the early years, and prototypes have been on test since June, 1957. The November firing was the second attempt to fire the missile over its full range of 6325 miles, and was described by jubilant U.S. Air Force men as completely successful.

Atlas is intended to carry 3-megaton fusion bombs from America to other continents, but Convair Astronautics who make this missile made the following significant comment: "The flight demonstrates the range capabilities of the Atlas. . . . But more than this, the flight clearly demonstrates the Atlas's potential for employment in the peaceful development of scientific vehicles for the exploration of space." . . . A viewpoint which ties in with Professor Lovell's closing remark in his fourth Reith Lecture on 30 November: "The fate of human civilization will depend on whether the rockets of the future carry the astronomer's telescope or the hydrogen bomb."

Professor Lovell also gave some interesting figures on the high cost of big rockets. The ill-starred Vanguard cost 120 million dollars to develop and "this must be a small part of the sums already spent in the U.S.A. on the . . . Explorer satellites and lunar probes. The only guide we have is the statement that in the fiscal year 1957 expenditures for missile procurement are estimated at over 3000 million dollars . . . five times . . . the 1955 figure. After the successful test of . . . Black Knight in September, which is capable of forming only one part of a satellite launching rocket, the cost of its development was given as £5 million; the rocket range at Woomera cost £50 million. The recent creation of the National Aeronautics and Space Administration with an actual budget this year of 300 million dollars and a projected budget of 1000 million in 2 years' time gives a new and refreshing sense of well-being and unity to the American space projects. The deplorable nature of the competition which has led to this transformation has hastened the development of space research beyond anything which was conceivable a few years ago."

[*To be continued*

An Astronautical Display Panel

By A. E. SLATER

Manned space-flight in all its stages is explained in neatly compressed form on a coloured wall chart produced by the Convair Division of the General Dynamics Corporation. A photograph of the chart is shown on the opposite page.

The distance scale, giving nautical miles, is shown on both sides. It is logarithmic, so that, although the first $\frac{1}{4}$ in. extends only 10 miles to the beginning of the stratosphere, the next $\frac{3}{4}$ in. takes us into the ionosphere at 100 miles, and the next to 1,000 miles, just beyond the farthest point of the second Sputnik's orbit. At this rate of scale compression, by the time we have reached the top of the diagram we are out beyond the Milky Way and travelling among the distant nebulæ. One point of special interest is the division between "translunar" and "interplanetary" space, at just a million (10^6) miles high; this is the distance beyond which the effect of the Sun's gravitational pull outweighs that of the Earth and Moon combined.

Among the planets, Uranus and Neptune are omitted for lack of (diagrammatic) space, but Pluto is shown beyond Saturn. Mars is rather inconspicuous beside Venus, and its accompanying symbol seems to have been forgotten. Lower down, the various objects are labelled with words.

The scale along the bottom represents thousands of feet per second; i.e. the figure 10 means 10,000 ft./sec., or very nearly 2 miles/sec. These velocities are the so-called "ideal velocities", meaning the velocity which a space-ship would have to attain in order to make a particular voyage. In practice, a rocket vehicle would have to use up more fuel than that theoretically required merely to accelerate it to the "ideal velocity"; the extra fuel is needed to overcome gravity while the ship is accelerating, and also to counteract atmospheric drag, if any.

For reaching satellite orbits and other positions depicted near the bottom of the diagram, the "ideal velocity" shown applies to a take-off from the Earth's surface; but for voyages to planets it is the velocity needed for getting from a satellite orbit encircling the Earth (at a height of 300 nautical miles) to a similar orbit round the planet being visited.

For example, in the diagram Saturn lies on the "110" vertical line, so a ship leaving an orbit 300 nautical miles above the Earth would have to accelerate to 110,000 ft./sec. to reach an orbit round Saturn. The Moon, however, is a special case; it will be seen that the "ideal velocity" for circumnavigating it is only 10,000 ft./sec., but for landing and taking off again the ideal velocities for each manœuvre add up to about 36,000 ft./sec.

Nearer to the right-hand side of the diagram, the different kinds of propulsion suited to voyages of various distances are shown; it will be noticed that they overlap to some extent. Alongside the column showing their range, the various types of vessels suitable for these propulsion systems are shown pictorially.

We start near the bottom with a manned glider coming down at supersonic speed after making several circuits of the Earth in a satellite orbit. Higher up are, on the right, some instrumented satellites (the vehicles in this column are not all drawn to the same scale), and on their left various high-altitude devices such as winged and ballistic rockets, with, above them, the V-2, the "Bumper" WAC, and an imaginary three-stage research rocket. The object with two paddle-like projections is a manned satellite.

Higher up come a vessel for circumnavigating the Moon and one for landing on it; both will start from satellite orbits. Then we see a couple of spheres joined together; they are collecting solar energy for operating an arc-heated jet. Two more chemically-driven vehicles follow, side by side; the one on the left has jettisonable tanks, and that on the right operates on high-performance liquefied gas needing large tanks with a big volume-to-surface ratio.

Above these we have a nuclear vehicle, with its passenger gondola well away from the atomic pile the other side of the hydrogen tank; it might be refilled from frozen ammonia or methane picked up from satellites of Jupiter or Saturn for a return voyage. Finally, of the upper two vehicles, the lower of the two has an ion drive, and the one at the top is driven by photons, whose light would be of too short wave-length to be visible. But the original occupants of these vehicles of the far future would never reach the stars: only their descendants would arrive there.

INTERGALACTIC SPACE
INTERSTELLAR SPACE
INTERPLANETARY SPACE
TRANSLUNAR SPACE
CISLUNAR SPACE
TERRESTRIAL SPACE
ATMOSPHERE
LUNAR CIRCUMNAVIGATION
LUNAR LANDING
INHABITED SATELLITE
I.C.B.M.
VANGUARD
BUMPER WAC
TERRESTRIAL AUTOMATIC SATELLITE
V-2 / VIKING
BALLISTIC
I.R.B.M.
SATELLOID
V-2
RAIDER
INTERCONTINENTAL
TRANSCONTINENTAL
UPPER ATMOSPHERE
10 20 30 40 50 60 70 80 90 100 110 120 130 140
NUCLEAR (FUSION)
ELECTRICAL (ION)

Danger—Moon at Work!

By ALICE COLEMAN

Many a responsibility laid at the Moon's door has died an old wives' tale of little more than green cheese credibility. Some, however, retain a scientific foundation, and among these are the twin ideas that the Moon influences the frequency of earthquakes and that it can trigger off volcanic eruptions.

Air, sea and solid earth all experience tides raised by the attraction of the Sun and Moon. The Earth, as the most rigid of the three, undergoes the least deformation, nevertheless, its rise and fall is measurable, and is of the order of 50 cm. at its maximum. This is the movement which is claimed can influence much larger geophysical movements and affect the timing of quakes and eruptions.

Earthquakes

When the two sides of a geological fault or fracture move against each other, the grinding motion sends out vibrations or tremors which are experienced as earthquakes. For example, the San Andreas fault responsible for Californian quakes is a great fracture trending from north-west to south-east. The coastal side of the fault is gradually being pushed towards the North Pole at the rate of 15 ft. per century, and vertical displacement is also in evidence. The forces involved probably act continuously but for a certain time the stress can be absorbed as increasing strain in the rocks. Eventually the accumulation of strain rises to a breaking point. The rocks can accommodate no more: they rupture, and earth tremors are set up.

The final increment of stress may be very minor, as long as it is enough to boost the accumulated total to a breaking point. Thus, although tidal deformation alone cannot create an earthquake out of stable ground, it is sufficient to touch off such a movement where conditions of near-instability already exist.

The founder of the hypothesis of a lunar influence upon earthquakes was a nineteenth-century Frenchman named Alexis Perrey. To test the hypothesis empirically he collected about 23,000 records of days with earthquakes from the year 1751 to 1872, and analysed their frequency distribution in time. The results led him to formulate three laws attributing earthquake frequency to changes in the Moon's phase, its distance from the Earth and its elevation in the sky.

(*a*) *The Phase Factor*

It is a well-known fact that every fortnight, at the time of new and full Moon, there occur particularly high and low tides, the springs. The vertical rise of spring tides from their lowest to their highest level may be nearly three times the range of the moderate neap tides which occur at the time of half Moon. The astronomical reason for this difference lies in the respective positions of the tide raising bodies, the Sun and the Moon. At the syzygies (new and full Moon) both bodies are arranged in a straight line with the Earth, so that each reinforces the other's tide-raising force. At the intervening quadratures, however, the Sun, Earth and Moon form a right angle, with the result that the two sources of tidal attraction offset each other and only muted tidal amplitudes ensue.

The same principle affects the tides of the solid body of the Earth. Since the Moon can raise tides over twice as high as those of the Sun, the combined effect of the two bodies at the syzygies is nearly three times as great as their effect at the quadratures, when the Sun offsets nearly half the Moon's influence. The time of syzygy, therefore, should produce substantially more effective triggering of earthquakes than the time of quadrature.

Perrey found that 12,347 earthquake days occurred in the weeks centred on the syzygies as compared with 11,601 in the weeks centred on the quadratures, an excess of 6·43 per cent. The validity of this large statistical sample is enhanced by the fact that when the total time span is broken down into eight shorter periods the frequency at the syzygies again exceeds that of the quadratures in every case. Thus a positive correlation is obtained between the time of syzygies and an increased number of earthquakes.

Perrey's method of counting "earthquake days" was designed to eliminate repetitions of the same earthquakes reported from different places, a mistake difficult to circumvent in the period prior to seismographic records. This meant, however, that if two or more independent earthquakes occurred in a single day they would be given the weight of only one. Hence, if the influence of the syzygies is real, the tendency for more than one quake to occur on the same day would be greater at these times than at the quadratures and Perrey's totals would be too small by a greater factor at the former than at the latter times. The figure 6·43 per cent. for the excess of syzygy over quadrature quakes would therefore be a minimum figure, and later analyses based on seismograph records should reveal a slightly higher percentage. This expectation can be used to some extent as a check on the hypothesis.

C. G. Knott in 1897 considered 7,000 Japanese earthquakes observed over a period of 8 years. These led him to conclude that the syzygial influence is "particularly in evidence," and indeed the percentage of excess shocks of syzygial over quadrature weeks is 7·7 per cent. while for 3 days at each quarter it is nearly 12 per cent.

Leo A. Cotton, who applied probability tests to Knott's statistics in 1922, believed that the chances against obtaining the amplitudes indicated for random events are about 400 to 1. This is equivalent to a 400 to 1 vote of confidence in the probability of Perrey's first law.

(*b*) *The Distance Factor*

Perrey's second law states that the frequency of earthquakes increases at the times when the Moon approaches the Earth most closely. This occurs once every month in that part of the Moon's orbit called perigee, which is about 221,500 miles distant from the Earth. Conversely the tidal effect should be much weaker a fortnight later when the Moon is at the opposite end of its orbit, apogee, 252,700 miles from the Earth. As tidal attraction varies inversely as the square of the distance between the two bodies, this difference of 31,200 miles can be quite significant. Moreover, the Moon speeds up in its orbit in the neighbourhood of perigee and this also may produce seismic effects.

Perrey compared the number of earthquake days occurring in the 5-day periods centred on perigee and apogee respectively. For the period 1843 to 1872 there were 3,015 shocks associated with apogee, and 275 more with perigee, an excess of 9·1 per cent. The corresponding excess for 1801 to 1850 was 9·8 per cent.

Again, we may argue that Perrey's unit, earthquake days rather than individual earthquakes, is likely to mask more shocks at perigee than at apogee. Later figures based on seismograph records ought, therefore, to reveal larger excess percentages at perigee.

Knott's Japanese figure reveals 10·3 per cent. more perigeal than apogeal earthquakes for 5-day periods, and 13 per cent. more for 3-day periods. In 1934 another high percentage was announced by a Spanish Jesuit, Luis Rodes, who analysed 2,242 records registered at the Ebro observatory from 1914 to 1932. This centre is fairly remote from any active earthquake focus which might have had a preponderant local effect upon the frequency of quakes. Rodes found that on the day the Moon was in perigee, shocks were 15 per cent. more numerous than when it was in apogee. Furthermore, a comparison of the 7-day periods centring on perigee and apogee respectively, raises the disparity to 20 per cent., because the peak of seismic activity tends to occur 2 or 3 days in advance of perigee. This is a reasonable tendency, geologically, as the required increment of stress necessary to trigger off a quake may be reached at any time while the tidal force is quickly building up to its maximum, and would only occasionally exactly coincide in amount with the maximum itself.

Figures as high as 13, 15 or 20 per cent. seem more than enough to demonstrate the validity of what is claimed to be merely an ancillary effect in promoting earthquakes.

The Moon makes a complete circuit from perigee to perigee once every 27·55455 days, whereas the two syzygies occur in a month of 29·53059 days. This means that perigee may be reached at any phase of the Moon, and that the phase and distance factors in the raising of the solid tide may operate at different times, or in coincidence: in the latter case they reinforce each other to give a particularly strong influence.

(*c*) *Perrey's Third Law*

Perrey was prevented by the onset of blindness from completing the empirical tests of his third law, that earthquake frequency increases in the meridian over which the Moon is currently passing. Actually this law has failed to survive statistical examination and L. A. Cotton has explained the theoretical reason for this. When the Moon was closest overhead its gravitational attraction is the same on both sides of a fault, and unlikely to cause differential movement. The maximum differential stress will occur when the Moon is low down on the horizon. In this position the area on the moonward side of the fault experiences a force directed towards the Moon while the ground on the opposite side experiences a much lesser attraction, which, if less than the average attraction of the Earth as a whole, may result as a small force directed away from the Moon. (This operates on the same principle whereby the Moon raises on the opposite side of the Earth from itself, an ocean tide which is directed away from it.) These differential stresses produce a tensional divergence of the ground in the neighbourhood of the fault, which if of sufficient magnitude may precipitate an earthquake. This tensional mechanism would be strongest at the time of the most powerful tides, namely at the syzygies and at perigee.

The combined tidal effects of the Moon and Sun are termed lunisolar influences. Some geophysicists are unwilling to admit that lunisolar influences play any rôle in determining seismic frequency, but for volcanic eruptions the case is stronger, and at least one volcanologist believed in them to the extent of literally staking his life upon them.

Volcanic Eruptions

Lunisolar influences upon volcanoes operate in the same way as for seismic activity. The basic causes of eruptions are internal to the Earth and tidal stress is but a minor mechanism determining certain details of timing.

Once an eruption is in progress there exists at or near the surface a body of hot lava, which, because of its fluidity and natural tendency to rise, might be considered even more responsive to the tide-raising forces than the ordinary solid crust. As an eruption may last for weeks, its duration often spans several syzygies and quadratures, and possibly several times of perigee, as well. Corresponding with these periods eruptive activity is observed to pass through a series of peaks and lulls. By measuring and plotting such features as the height of the lava column, it is possible to construct graphs of eruptive activity which can be checked for time coincidence

against lunisolar influences. Fig. 1, a graph of the 1907 Stromboli outbreak compiled by F. A. Perrett, shows very clearly how lunisolar effects have been superimposed upon a broader increase and diminution of volcanic manifestation due to internal causes. The peaks correspond closely to the syzygies, and as at this time perigee was closely coincident with the opposition of the Sun and Moon it reinforced the syzygial peaks and caused no interruption of the lulls associated with the quadratures.

Lunisolar correspondences as remarkable as this have contributed significantly to the science of predicting eruptive behaviour. Perrett himself selected the dates of quadratures for crater excursions to make close observations of volcanic activity during eruptions, and his faith in the system seemed justified by his successes. Furthermore, when the 1923 eruption of Etna seemed to have died down, Perrett was able to counsel justifiable caution, as a strong lunisolar maximum was at hand on June 27, and did, in fact, produce a recrudescence of activity.

The art of forecasting volcanic dangers has clearly made great strides, and there is hope for the future that the system will be made even more accurate and also extended to cover earthquake hazards. In the process a great deal more attention must be given to the natural Earth satellite, and its terrestrial effects.

From the Lunar Angle

Now that lunar travel to the Moon is almost a practical possibility it is interesting to enquire whether the Earth will constitute as great a source of danger to the lunar explorer as the Moon does to the inhabitant of Naples or San Francisco. The Earth is the larger, and its gravitational attraction greater, so it might at first sight seem to play a larger rôle in lunar eruptions and moonquakes. In reality, however, this is not so. The Earth's gravitational effect upon the Moon has been so great that it has virtually stopped the Moon's rotation. The Moon always turns the same face to the Earth, with only slight librations. The local gravitational force at every point on the Moon's surface therefore remains practically constant. Any seismic adjustments that could be made to it were probably completed quite early in the pre-Cambrian period, and since then very little has happened at all. Spacemen need not fear the natural disasters of the Moon: in all probability, half an hour of their own walking will create more surface changes than any Moon mechanism (excluding meteorites) has been able to produce in a hundred years.

Kazimierz Siemienowicz—Polish Rocket Pioneer

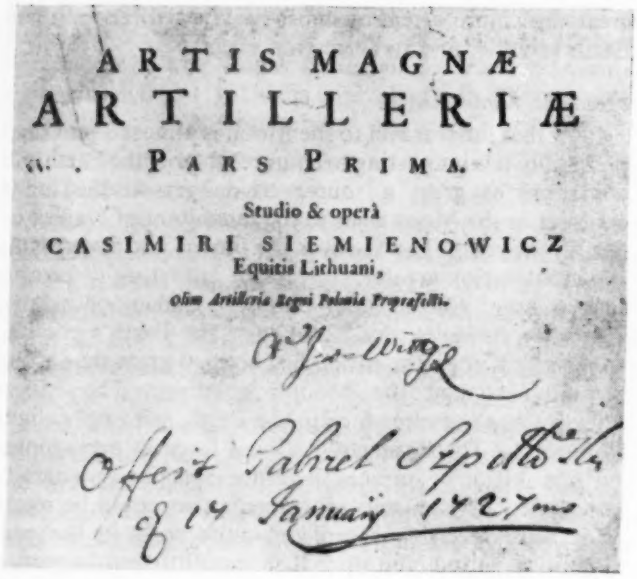
(Condensed from an article by M. SUBOTOWICZ)

Translated by Mrs. N. E. Orna (Polish Cultural Institute Information Officer)

Although the idea of employing rockets for space flight is comparatively recent (their use for this purpose was first seriously suggested by Tsiołkowskii in 1896), they have in themselves a long history, dating back in China to at least the mid-thirteenth century (the first recorded reference is in a chronicle of 1232), and in Europe to 1249 (when the Arabs attacked the Iberian peninsular with rockets). Early European writings on rockets include the *Bellifortis* (1405) of Konrad Keyser von Eichstädt, and the Italian de Fontana's *Bellicorum Instrumentorum Liber* (1420). These and other similar works treated the subject from a military point of view, and so also did the first extensive treatment of rockets from the pen of a Polish author.

The work in question was the *Artis Magnæ Artilleriæ pars prima* of Kazimierz Siemienowicz, which appeared in Amsterdam in 1650 (a compatriot, Marcin Bielski, had written about rockets in 1569, but this was the first Polish scientific study). Although he was concerned primarily with rockets as weapons or signals, it appears that Siemienowicz was the first writer in the world to put forward certain ideas about rocket construction that are today of paramount importance for their use in space flight. In particular, he discussed multi-stage rockets, multiple rockets and rockets with delta-type wings.

Chodynicki, writing in 1833, called Siemienowicz the "father of artillery" and the "first Polish writer on



ARTIS MAGNÆ
ARTILLERIÆ
PARS PRIMA.

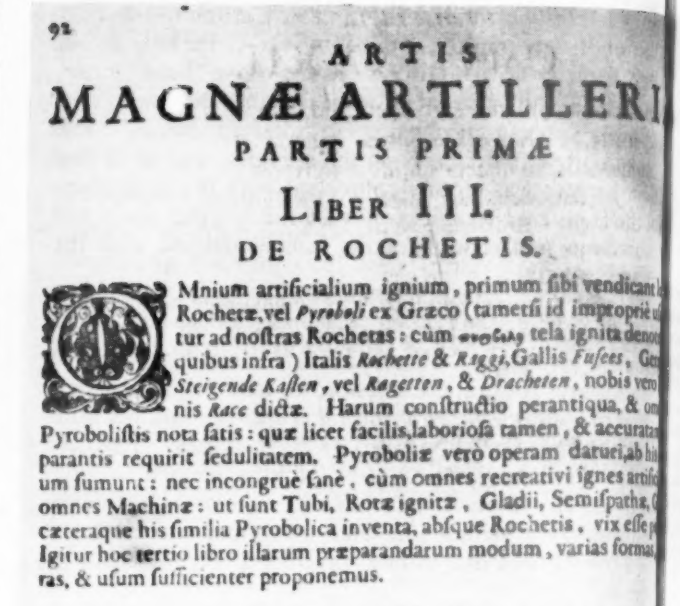
Studio & operâ
CASIMIRI SIEMIENOWICZ
Equitis Lithuani,
olim Artilleriæ Regni Poloniæ Præfecti.

Offert Gabriel Szpotta M.
d. 14 Januarij 1727mo

the art of artillery". His work was translated from the original Latin into French, German, English* and Dutch. The English translation was derived from the French version, and the translator speaks of the Latin copy as a rarity outside Poland, venerated by the Poles as a treasure.

Little detailed information about the life of Siemienowicz has come down to us. He certainly came from Lithuania, then a part of Poland, for the name is Lithuanian. He was well grounded in the humanities, and had an acquaintance with ancient history and a deep knowledge of the art of war. The elegant Latin in which the *Artis* is written testifies to his knowledge of the classics. He travelled much abroad in his young days, and on his return King Władysław IV and his chancellor Jerzy Ossolinski, a great connoisseur of military matters, "having regard to his great skill in the science of artillery" sent him abroad again. The theoretical and practical knowledge gained in his travels abroad served to make Siemienowicz one of Europe's greatest artillery experts, whose fame spread beyond his own country. Having returned again to Poland, he became an officer in the Crown Artillery. At this period he wrote a two-part monograph on artillery. King Władysław IV having become acquainted with the work ordered that it should be printed, and it appeared in Amsterdam some two years after the King's death, in 1650. Only one part was printed, for Siemienowicz died in 1651. The manuscript of the second part was for a time in a library at Lubartow and later in the Zaluski Library in Warsaw, and was seen at the end of the nineteenth century in St. Petersburg. In the German translation which appeared in 1676 there is a completion of the second part by

* *The Great Art of Artillery* of Casimir Simienowicz, formerly Lieutenant-General of the Ordnance to the King of Poland. Translated from the French, by George Shelvocke. London 1729.



92

ARTIS
MAGNÆ ARTILLERI
PARTIS PRIMÆ

LIBER III.

DE ROCHETIS.

OMnium artificialium ignium, primum sibi vendicant
Rochetæ, vel *Pyroboli* ex Græco (tametsi id impropriè u
tur ad nostras Rochetas: cùm [illegible] tela ignita denot
quibus infra) Italis *Rochette* & *Raggi*, Gallis *Fusees*, Ger
Steigende Kasten, vel *Rageten*, & *Dracheten*, nobis vero
nis *Race* dictæ. Harum constructio perantiqua, & om
Pyroboliſtis nota satis: quæ licet facilis, laborioſa tamen, & accuratæ
parantis requirit ſedulitatem. Pyroboliæ verò operam daruei, ab hi
um ſumunt: nec incongruè ſanè, cùm omnes recreativi ignes artifi
omnes Machinæ: ut ſunt Tubi, Rotæ ignitæ, Gladii, Semiſpathæ,
cæteraque his ſimilia Pyrobolica inventa, abſque Rochetis, vix eſſe
Igitur hoc tertio libro illarum præparandarum modum, varias formas
ras, & uſum ſufficienter proponemus.

CAPVT I.

**De Formis ſeu Modellis, tam Ligneis quàm Metallicis, ad e
endas Rochetas Parvas, & Mediocres.**

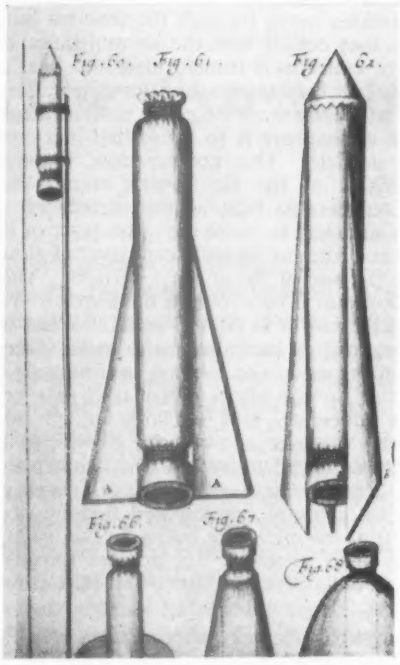
Modus. 1.

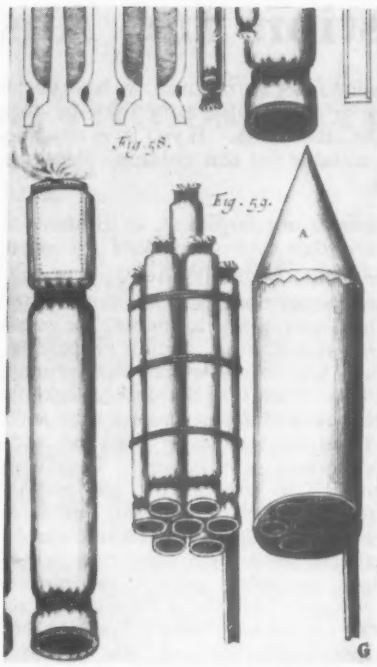
FOrmæ, ſive Modelli ad conſtruendas Rochetas, tum ex æ
aurichalco, tum ex lignis ſolidioribus: ut ſunt Cupreſſus, Palm
ſtanea, Buxus, Nux Italica, Juniperus, Prunus ſylveſtris,
hiſce ſimilibus, immò ex Ebore, & lignis Indicis, parari, & quæ
tiſſime ab intus, & ab extra tornari ſolent. Proportio tam altitudinis,
craſſitiei, & ornamentorum, variat apud artifices; juxta illud, quot
tot ſenſus. Quantùm ad formas in quibus Parvæ & Mediocres R
conſtruuntur. (Parvas Rochetas autem voco, quæ in orificiis aliquot
lium globorum plumbeorum diametros habent; ſed unam libram
cedunt: Mediocres verò quæ ſunt 1 ℔, & 2; trium verò vix concei
Majores denique à 2 ℔, uſque ad 100 ℔ ſumi poſſunt) Iſtarum du
dos hic exponam: Majorum verò ſequenti capite rationes docebo.
itaque modus eſt hic. In Figura N. 20, finximus diametrum orifi
mæ A B, eſſe 1 ℔ plumbei globi (uſu enim apud Pyroboliſtas recepto
ut orificia formarum & Rochetarum menſurentur diametris glo
plumbeorum) Altitudo formæ ab Y, uſque in E, eſt 7 diametrorum
ab E verò uſque in G, eſt altitudo Stylobatæ, qui ſubponitur form
Rocheta oneratur 1 diametri cum ½. Hæc habet in medio Cylindrum,
ſus eſt per diametrum C D ½: Altus verò 1 diametrum orificii. H
indro, inſiſtit dimidius Globus L O P M, cujus diameter L M eſt

All three illustrations in this article are from Siemienowicz' *Artis Magnæ Artilleriæ*.

Daniel Elrich; this author says that Siemienowicz was prevented by death from completing his work.

The printed volume is divided into 5 books; there are 304 pages, 206 text illustrations and 22 plates. Possibly because of the rarity of the work, it is barely mentioned in the specialist literature on rockets published outside Poland. Willy Ley in his *Rockets and Space Travel* mentions it only in the bibliography and not in the text. Siemienowicz is briefly mentioned by A. Sternfeld (1937)





as having speculated on multi-stage rockets and three of his illustrations are used incidentally in an article by Professor T. von Kármán in *Inter Avia* (1953). Beyond that there is no mention of him.

Two types of rocket may be distinguished: the multi-stage, where several propulsion elements are set in motion one after the other, and the multiple rocket where individual smaller rockets assembled as elements of a larger complex are set off simultaneously.

In the application of rockets to problems of space flight, the multi-stage rocket is of the utmost importance in attaining escape velocity. Kazimierz Siemienowicz was the first scientist in history to mention the actual fundamental possibility of the multi-stage rocket. He wrote of these rockets incidentally, so to speak in the margin of the over-riding military interest in rockets. He mentions multi-stage rockets for signalling and also as rocket projectiles. The whole of the third book of the *Artis* is devoted to rockets propelled by gun-powder.

One of the variants mentioned is the multi-stage rocket. The drawing given by Siemienowicz (Fig. 7 in this article)* does not leave room for any doubt that what he describes is in fact a three-stage rocket without wings. Each stage is a rocket complete in itself, with fuel, jet and fuse. The third stage is the cargo of the second, the second of the first. It is not ascertainable whether he ever constructed a multi-stage rocket powered by gun-powder. Moreover, among Siemienowicz's sketches there is a drawing showing a multiple arrangement with 7 rockets.† This was of course intended for signalling. Other projects advanced by Siemienowicz concerning rockets include a one-stage rocket with a delta wing.‡

* Fig. 49 in the *Artis*. Described on pp. 156–7 of the English translation.

† Fig. 59 in the *Artis*. Described on p. 160 of the English translation.

‡ Fig. 62 in the *Artis*. Described on p. 161 of the English translation.

COVER

Thor rocket engine. This liquid propellant engine develops approximately 150,000 lb. thrust and was used to provide the first stage boost for Pioneer 1, the intended moon-probe, which travelled 79,000 miles into space on October 11–12, last year. Thor is also being used as a first-stage for sending 1,300 lb. satellites into polar orbits from Vandenberg Air Force Base, California.

Question and Answer

Since many inquiries are received, we have decided to answer some of them in print in the hope that the answers may be found useful to others also. If you have any questions which you feel are suitable for this column, please send them to me.—EDITOR.

If solid propellents are inefficient, as is stated in most textbooks, why are they now being used for certain stages of satellite launchers?—W. S. RIVERS.

Solid propellents are not inefficient; they burn without losses of available heat energy due to incomplete combustion or to bad propellent distribution. Solid propellent rockets are extremely robust and simple devices when properly developed, and they are easy to start by pyrotechnic ignitors. They are highly reliable, particularly in smaller sizes such as are used in the second and third stages of Explorer, and do not need pre-flight preparation or servicing. These grounds would serve well enough to support the use of solid propellent rockets in satellite launching vehicles, but, in addition, it is demonstrable that although the attainable specific impulses of currently available solid propellents may not be as high as with some liquid propellent systems, the important criterion, which is the product of vehicle or stage mass ratio and specific impulse, can be greater with solid propellent rockets than if a liquid propellent engine is used, due to the much lighter hardware.

While solid propellents are never likely to surpass liquid propellents in specific impulse, it is quite possible that solid propellents will be made which will have specific impulses of the order of 270 seconds at sea level, thus being more than competitive with such liquid propellents as liquid oxygen/kerosene or liquid oxygen/hydrazine.—E. S.

What is the reason for astronomers' uncertainty as to the distance of Venus? In "Nebula Science Fiction", Dr. A. E. Roy says that its minimum distance is 26 million miles, but other books say that the proper value is only about 24 million miles. G. RICHARDS.

Astronomers are not so uncertain about Venus's distance as Mr. Richards believes.

When it is desired to show the large variation in distance between Venus and the Earth between superior and inferior conjunction, it is usual, as was done in the article which Mr. Richards mentions, to take the close approximation of circular, coplanar orbits for the planets. This gives us the 26 million miles at inferior conjunction and the 160 million miles at superior conjunction.

If, however, we ask ourselves how close the planet Venus can approach the Earth over many synodic periods, we must take into account with the longitudes of conjunction (1) the eccentricities of the orbits, (2) the inclination of Venus's orbit to the ecliptic, (3) the longitude of the line common to both orbital planes. In addition we must remember that, over thousands of years, due to the mutual gravitational attractions of the planets, the orbits are shifting in position, in size and in shape. Calculations based on these factors show that at rare intervals Venus can approach Earth to within 24 million miles but on average, the planet at inferior conjunction is about 26 million miles away.—A. E. ROY.

Editorial Note.—In his article in "Nebula Science Fiction", Dr. Roy stated: "The distance of Venus from us can vary from 26 million miles at inferior conjunction to 160 million miles at superior conjunction".

Why does a meteor shine when it enters the Earth's atmosphere? —A. J. LORRIMER.

Meteorites are small particles of iron, stone, or a mixture of these materials, which enter the atmosphere with velocities of up to about 45 miles per second with respect to the Earth. As these particles move through the tenuous outer layers of atmosphere, they collide with the air molecules, and some of the energy of collision is transformed into heat energy. As the meteorite falls further into the atmosphere, the air becomes denser and collisions more frequent, until at heights of about 60 miles the atmosphere is so dense that it is compressed by the falling particle. This compression, together with the frictional effects of the air flowing round the meteorite, generates considerable heat at the surface of the particle. This heat is sufficient to cause the outer layer of the meteorite to vaporize and form an incandescent layer of glowing vapour, many times the size of the original particle. This is why the meteorite shines as it falls toward the Earth. We cannot see the meteorite itself; it is far too small. What we see is the relatively huge ball of incandescent vapour. Since the energy of motion of the meteorite is being continuously transformed into heat, the particle slows down as it gets smaller. If it slows down sufficiently, and was large enough initially, it will not completely vaporize, and will stop glowing as it approaches the very dense lower region of the atmosphere. Thus a remnant will reach the Earth's surface. Such pieces, when found, exhibit signs of melting and flowing of the surface. It is doubtful if the meteorite burns, in the usual sense of the word, as there is probably not enough oxygen to support combustion over most of its path.—N. H. LANGTON.

Correspondence

SIR,—I would like to correct a rather misleading statement in Dr. Guignard's excellent article "Spaceman Overboard" in the July issue of *Spaceflight*, especially as it concerns a matter I have several times raised in my own books (see e.g. *Earthlight*, chapter XIX).

To quote from Dr. Guignard: "The belief is held by some enthusiasts that because a man can draw and hold a deep breath for a minute or more, an experienced astronaut may . . . make brief excursions into space without protection, living upon the oxygen held in his lungs and bloodstream. This is of course fallacious, as it is quite impossible for a man to maintain atmospheric pressure within his chest against a hard vacuum outside."

The error lies in the first sentence; the second is correct but irrelevant. There would be no question of *holding* breath before exposure to space; one would deliberately exhale first (as I pointed out in *Earthlight*) and then keep the mouth open so that the last trace of air could leave the lungs. The secret of unprotected survival in space (assuming that it is possible) will be preliminary hyperventilation or deep-breathing, which saturates the bloodstream with oxygen and flushes out the CO_2, so that the breathing reflex is inhibited. Once this is done then even if the lungs are empty there is no desire for breath for several minutes. This fact is well-known to native divers, most of who *exhale*, not inhale, immediately before submerging.

I do not know how long this trick would extend consciousness in space, but will be surprised if the period is as little as 1 minute, after which death would ensue as a result of ebullition of the blood rather than suffocation. And if anyone thinks this unlikely, may I ask how many physiologists would have predicted that men could stay underwater for 10 minutes, or descend to 150 feet (5 atmospheres pressure!) *without any mechanical aids or breathing equipment*? Yet these things have been done, and some day we will be equally astonished by what trained men can endure in space.

Yours faithfully,

ARTHUR C. CLARKE.

Colombo,
Ceylon.

The Extent of the Lunar Atmosphere

By GEOFFREY TURNER, F.R.A.S.

Many non-scientists challenge the confidence of astronomers in reaching conclusions concerning the atmospheres of the Moon and planets; their argument being that they cannot be sure since they have never been there. I should like to attempt a description of the observations and experimental data from which the conclusions are drawn.

It is essential that potential interplanetary travellers should have an understanding of the nature and extent of the atmospheres on the bodies which they contemplate visiting. Since the Moon is the Earth's closest neighbour, it is very likely that it will be the first place for exploration. It is now general knowledge that some protective apparel will be required for the explorers when they leave their vehicle, and the outstanding reasons for this are the absence of a substantial atmosphere and the extreme temperature range which will be encountered on the surface of the Moon.

It is easy to say that the Moon has lost all of its atmosphere, since the high temperatures on its surface cause high molecular velocities which are considerably in excess of the Moon's escape velocity. This might lead to the accusation that I am trying to blind non-technical readers with science, therefore I shall immediately try to put this right by explaining these facts in more simple terms.

Deductions from the Kinetic Theory of Gases

In this atomic age, there is no difficulty in understanding that the tiniest units of matter are atoms; they are the bricks from which all substances are built. Atoms themselves are normally too reactive to remain by themselves for long, and so they tend to join up with others. If atoms combine with others of a different type, a compound is formed; a simple example is the combination of two hydrogen atoms with one oxygen atom to form one molecule of water. If, however, the conditions in which an atom finds itself are not conducive to combination with different atoms, then the only thing which it can do is to form molecules by partnering with other atoms of its own kind. For instance, two atoms of oxygen form a molecule of oxygen, similarly with two hydrogen atoms. This formation of molecules is quite well defined and it takes measurable amounts of energy to break up these partnerships and, conversely, measurable amounts of energy are involved when molecules are formed.

The proof of this, although simple and beyond any doubt, is not relevant here. The only atoms which do not form molecules are those of half-a-dozen inert gases which, by virtue of their atomic construction, are completely unreactive; they are by no means freaks, for they fit perfectly into the general pattern of the elements.

My task, now, is to show that molecules are always in motion and to explain their general behaviour in this respect. The simplest demonstration of molecular motion in the phenomenon of Brownian Movement. If a fine powder, such as pollen, is put into water and examined under a microscope, it will be seen that the particles are never still; they are continually wandering about, completely independent of each other, and in all directions. This phenomenon was first noted by Brown in 1827, and according to Wiener in 1863 "the movement does not originate in the particles themselves, nor in any cause exterior to the liquid, but must be attributed to internal movements characteristic to the fluid state." The reason for this motion is that the particles suffer unbalanced impacts with the molecules of the surrounding fluid. It should also be noted that the rapidity of the Brownian movement is proportional to the temperature, measured from the absolute zero at minus 273° C.

There is now no doubt that molecular motion is the cause of Brownian Movement, and the observations are not only confined to powders in water; for instance, it could be observed on smoke particles in a gas. The fact that the rapidity of the movement increases with increasing temperature shows that the speed of the motion of the molecules increases with temperature. This is reasonable, since, if the gas is heated the molecules are given more kinetic energy causing them to move with higher velocities.

The term "Escape Velocity" should hardly need explaining now that people are so familiar with the requirements of interplanetary vehicles. Suffice it to say that if a body can attain a given speed, known as the escape velocity, it can overcome the effects of the Earth's gravitational forces of attraction. This applies to all planets and satellites, although the actual velocity varies on account of the different gravitational intensities of other planets. The escape velocity depends mainly on the size and mass of the planet or satellite. On the Earth the escape velocity is 7 miles per sec.; but on the Moon it is only 1·5 miles per sec., whereas on the giant planet Jupiter it is 37 miles per sec.

The Lunar Atmosphere

Getting back to the motion of the molecules, it is now obvious that a molecule travelling away from the surface of the Moon at, or faster than, the escape velocity would

be lost by the Moon for ever. The question is, can a molecule reach the escape velocity and what are the chances of it leaving the Moon without colliding with another molecule if it attains that velocity?

We have much information about the molecular motion of gases at different temperatures and so it is only necessary to find out the maximum temperature on the surface of the Moon, in order to determine what the mean molecular velocity will be. This last step is quite easy. Just as we can focus the light of an object in a telescope, we can also focus the heat from an object, in the same telescope, on to a suitable measuring instrument and so determine the temperature of the body in question. Anyone who doubts this should try focusing the Sun, on the back of his hand, with a burning glass, and then reconsider whilst dressing his burn; he will, no doubt, find that the Sun's image is quite hot, as well as being bright. In the case of the Moon, the effect is not very strong, but Petit and Nicholson used the world's second largest telescope, the 100 in. reflector at Mount Wilson, for their experiments and found that the temperature of the hottest part, measured when the Moon appears full, is 134° C.

In calculating the mean molecular velocities at the maximum temperature of the lunar surface we use a simple formula relating the molecular weights of the gases in question with temperature and mean molecular velocities; the necessary formula is derived from laboratory experiments, in the first place, and well established kinetic theory. The molecular weight enters into the calculation in such a way that the velocities are found to be greater for the lighter gases such as hydrogen and correspondingly less for the heavier ones such as carbon dioxide and xenon. It must be clearly pointed out, however, that all molecules do not have the same velocity; because there are collisions between molecules, some are speeded up at the expense of others which are slowed down. The distribution of velocities above and below the mean value was first calculated by Maxwell as long ago as 1860 and is known as the Maxwell Distribution Law. In calculating the mean molecular velocities for the maximum temperature of the lunar surface we find that even the highest mean molecular velocity, for hydrogen, is still less than the escape velocity of the Moon. The rate at which the atmosphere is lost depends on the difference between the mean molecular velocities and the escape velocity since, if the difference is small, a large fraction of the molecules in the topmost layer will exceed the escape velocity, according to the Maxwell distribution, and leave the atmosphere.

Collisions in the lower layers then continually supply molecules of above average velocity to the topmost layer, and these can again escape into space. The result is that if the mean molecular velocity exceeds about one-fifth of the escape velocity the atmosphere "evaporates" away into space within a few thousand years, which is a very short time astronomically speaking.

Even after the escape of the major fraction of an atmosphere, the very slightest trace remains, and it is here that we are not yet certain how much there is. Estimates, based on different techniques, vary between a thousand millionth of the Earth's atmosphere, to one ten-thousandth of our own. Even though these estimates vary by a factor of a hundred thousand, it is quite certain that the lunar atmosphere is negligible from our point of view, and if we contemplate a visit to the Moon, we must take our own air and water.

Reviews

Charte der Gebirge Mondes. By J. F. Julius Schmidt. Berlin, 1878. Re-issued by Scientific Book Service, 663 Franklin Avenue, Columbus 16, Ohio.

The map of the Moon published in 1878 by Julius Schmidt is one of the classics of selenography. Apart from the map drawn 40 years earlier by Beer and Mädler, it was the first proper chart of the lunar surface, and represented a great advance in our knowledge of the Moon.

The map, in twenty-five separate sections, is here presented on a reduced scale. The quality of the reproduction varies from plate to plate, but is generally fair. There are many lunar observers who will welcome the opportunity to buy this famous map at comparatively low cost.

PATRICK MOORE.

How to Draw Rockets and Spaceships. Charles Sergeant. Studio Publications Ltd., 1958. 64 pp. 5s.

The title of this book speaks for itself. Starting with "a drawing lesson up to date," the author ends with instructions for drawing "space taxis, space paraphernalia and flying saucers." The present reviewer was frankly unimpressed with the results, but the book may well amuse the under-twelves.

S. W. ALLENS.

Radioastronomy and Radar. By J. G. Crowther. Illustrated by David A. Hardy. Methuen's Outlines, 1958. 10s. 6d.

The first 15 pages of this book deal with radar; the remainder with radio astronomy in all its aspects. It is aimed at the reader of school age, but many adults will find it equally interesting.

The book is decidedly successful; the author presents his facts well, and the result is a clear, concise introduction to the subject which should achieve wide popularity. There is also a bibliography, but this is rather short; the reader is referred to the book list in a companion volume in the Outline series, Patrick Moore's *The Solar System.*

The only major fault in the book is that the author is rather weak in spelling; "surprize" and "onto" are typical slips, unfortunate in a book which will be used in schools. However, this can be rectified in the next edition.

Special praise must be given to the artist, D. A. Hardy, for his excellent illustrations, which help to make this book interesting, useful, and excellent value for 9s. 6d. The reviewer recommends it strongly.

K. E. S.

[*Continued on page* 60

Minor Planets

By Lt.-Col. G. E. B. STEPHENSON, F.R.A.S.

The discovery by an Italian astronomer, Giuseppe Piazzi, at Palermo in Sicily, of a small planet on January 1, 1801, later to be named Ceres, produced the missing link in a peculiar mathematical sequence known as Bode's Law, representing the distances of the planets from the Sun.

Johann Elert Bode was a German astronomer who did much to popularize astronomy by publishing astronomical almanacs, maps, and the Law to which he drew attention. The law suggested that there was probably a planet revolving in an orbit between Mars and Jupiter. When, in 1781, Herschel discovered Uranus beyond the orbit of Saturn, and its distance from the Sun was found to agree with Bode's Law, astronomers were more convinced than ever of the existence of a planet between Mars and Jupiter.

An intensive search was organized for discovering this missing planet. Giuseppe Piazzi happened to be one of the team selected for this work, but before he heard about it, he happened to discover Ceres while checking his star catalogue.

During the next seven years, three more small planets were discovered—Pallas, Juno and Vesta—all with orbits between those of Mars and Jupiter. These small planets became to be known as *asteroids* because they looked like stars, but astronomers now favour the term *minor planets*. These four planets had diameters ranging from a hundred to five hundred miles, Ceres being the largest. One of these, Vesta, is often bright enough to be seen with the naked eye.

Search for further minor planets was continued unsuccessfully for nearly 40 years; astronomers were expecting to find planets as bright as the four already discovered. From 1845 onwards, minor planets were discovered with ever increasing rapidity, particularly since the employment of photography, first used by Max Wolf of Heidelberg in 1891. As the years went by, difficulty was not in finding a new planet, but in finding a new name for it! Over 1,500 names have now been given to these planets. The orbits of over 1,600 have been secured. There are probably many thousand undiscovered ones.

To give some idea of the sort of names which are now given to these planets, here are ten names from those most recently given: Aunus, Esperanto, Geographos, Inkeri, Lindbladia, Malmquista, Nurdenmarkia, Savo, Turku, Vinterhansenia.

Some minor planets are only a few miles in diameter. Most of them are probably irregular in shape because many of them vary considerably in brightness—no doubt exposing varying surfaces to the Sun's rays as they rotate.

LT.-COL. G. E. B. STEPHENSON

Most amateur astronomers have never seen a minor planet, yet nearly every year several, even apart from *The Big Four*, are bright enough and well placed for observers with 6-in. or smaller telescopes.

Tracking minor planets is interesting work, and there is always the chance of finding a new comet while observing a minor planet! Quite often a second minor planet will be found in the field of the one being observed.

For observing minor planets, an equatorially mounted telescope with a wide field of view is desirable. The writer uses a 6-in. f/4 reflector which he constructed ten years ago. This telescope is what is known as a *richest-field telescope*. The field of view is $1\frac{1}{2}°$, and magnification 24. The mounting need not be accurately constructed, and circles are not necessary.

Fine "hairs" of drawn glass should be fixed with minute dabs of some adhesive substance at the focus of

the eye-piece so as to form as large a square as possible in the field of view. For convenience, this square can be taken to represent four 1-in. squares of one's chart—the chart one is about to prepare. The eye-piece should be rotated until stars move parallel to the top and bottom of the square when the telescope is moved in Right Ascension.

Every year, the Institute of Theoretical Astronomy at Leningrad publishes a volume of *Ephemerides of Minor Planets* for the following year. At the end of the volume, ephemerides for longer periods are given for the brighter minor planets. Those planets conveniently placed with regard to the observer's latitude should be selected for observation.

From the ephemeris, plot the planet's path on a naked-eye star map. Select a star near to the path as a guide star. Mark this star boldly on the chart, mentioned above, and transfer to the chart from the map the *dates* of the ephemeris positions. Mark the date figures large, and lightly, in soft pencil. Remember that the ephemeris is only approximately correct.

In marking these dates the increased scale of the chart must be allowed for, and also the fact that the telescope will give an inverted view. The scale of the chart may be ascertained by noting how long a star near the celestial equator takes to travel from one side of the hair-lined square (in the eye-piece) to the other side. The star will travel at the rate of one degree in four minutes.

Aim the telescope at the guide star. Using a red-screened torch, mark in all the stars from the position of the guide star to the marked date corresponding with the date of observation. Ring and date all the stars. Ink in the stars, but not the rings and dates.

The next clear night, check all these stars and tick them off. Marks in stars up to the planet's new position and any stars not noticed the first night. Ring and date these, and erase the rings previously made—with their dates. Ink in the newly entered stars.

After a few nights' observations it will be found that one "star" has changed its position, and continues to do so. This one is the minor planet, and should be double-ringed, and, later, ringed and dated in ink.

From now on, it is best to mark on one's chart, *ahead* of the planet's position, only those stars which are *brighter* than the minor planet. This will help recognition. Fainter objects in rear of the planet's position should be marked in, in case one of these may turn out to be an object other than a star.

Each night, from the night that the minor planet is identified, an estimate of the brightness of the planet should be made by comparing it with a neighbouring star. The colour of the planet should also be noted, again by comparing its colour with that of a neighbouring star.

Occasionally stars are occulted by minor planets, when very accurate determinations of the planet's position can be made. In the absence of a chronograph or stop-watch, a metronome, ticking seconds, will enable timing to be carried out to one second without having to glance at a watch, except once a minute for checking the metronome. The minute hand of one's watch should be set to agree with the second hand, and the watch-time error noted, before and after observing, by comparison with broadcast time signals.

Once a minor planet has been identified, it can usually be picked up easily under worse observing conditions. The Moon is only a serious obstacle when fairly full and when near to the planet.

Continued from page 58]

The Boy's Book of Astronomy. By Patrick Moore. Burke Publishing Co., London, 1958. 143 pp., illus. 9s. 6d.

Let it be said at once that the author has produced an outstandingly good book. It represents an introduction to astronomy which can hardly be faulted, and though directed towards those of the under-18 age group, will be of great value to adult beginners also. The text is well-written, clear and concise, making very easy reading, and there is a tremendous amount of information put over in an attractive way. A feature of the book, too, is the great number of illustrations—over a hundred in all, ranging from line drawings to photographic plates. To produce such a book at a price of less than ten shillings the publishers must have printed a large edition, but doubtless reprints will be called for in due course.

The first chapter, "The Changing Skies," is introductory, and outlines general principles. In Chapter 2, "How Astronomers Work," instruments are described; there are some practical hints for the beginner, including an outline of how to make a simple telescope costing only a few shillings. The next chapters deal successively with the Moon, the Sun, the planets, and comets and shooting-stars, after which we come to the section dealing with the stars. "Other Suns" and "Some Interesting Stars" (doubles, variables, etc.) are followed by four chapters dealing with star recognition. The reviewer was particularly impressed with the stars maps, and with the method of using certain easily-found constellations, such as Orion and the Plough, as a method of finding the more obscure groups. Done in this way, star recognition becomes easy, and it is strange that other books have not adopted a similar system. Finally we come to "Galaxies" and "The Radio Sky," in which a summary is given of these relatively new branches of stellar astronomy. To make the book topical there is a 10-page chapter entitled "Flight into Space," in which astronomy is linked with astronautics, and it is shown how greatly the rocket experiments will help the astronomers themselves. There are appendices including a note about the London planetarium, and a "test-your-knowledge" quiz for anybody who wishes to see how much he (or she) has learned—answers are also provided!

Misprints are absent, and neither has the reviewer found any inaccuracies. The photographs include detailed views of the Moon and planets, and there are also stellar views; some of these pictures were taken with large telescopes, including the Palomar 200-in.

A refreshing feature of the book is that the author goes out of his way to stress that astronomy may become a practical hobby. When he describes any special form of object, he also tells you where to find it, and what you are likely to see with various forms of equipment. This is wise; the whole subject takes on a new interest when it becomes a practical instead of an armchair hobby.

This book should be found in all children's libraries, and is well worth a place in adult libraries also, since there is no suggestion of the common fault of "talking down". It could well become the standard juvenile introduction to astronomy. The present reviewer can only wish that it had been available when he himself first learned the fundamentals of the science over 40 years ago.

R. A. L.

Out and Around

By ORBITER

Orbiter surveys some of the current developments in astronautics.

"Off with their Heads"

In my previous survey I commented on some of the exciting rocket models available to U.S. youngsters.

Understandably this hobby of rocket firing could be dangerous. But the U.S. authorities appreciate it stimulates youthful interest in the fast-growing science of astronautics, and consider the pastime of importance to to the nation's future.

Therefore, instead of attempting to ban or limit the hobby, attempts are made to ensure proper supervision. For example, the Defense Department gave approval to Lt.-Col. Charles M. Parkin, an Army missile expert at Fort Belvoir, Va., to conduct a test programme to assist teen-age rocketeers. A local High School Rocket Club was selected as the first trial group to sample the programme.

Parkin took them on a tour of missile facilities, instructed them in the safe handling of rockets and propellants and ran a series of Army-supervised launchings of the Club's rockets. The safety aspect of all operations was particularly emphasised.

The experiment was a great success, and the Pentagon has given the green light to a nation-wide programme of Army assistance to the teen-age rocket movement! Upon request, amateur rocketeers may now use nearby Army ranges to test their missiles under Army supervision. More than 5000 young clubmen have already eagerly responded.

One cannot but contrast the U.S. attitude with the response that similar youthful activitiy in Britain would undoubtedly invoke. It is some time since the issue was put to test.

Pre-war members will vividly remember the occasion, in 1937, when the Manchester Interplanetary Society decided to spend the Easter Holiday experimenting on the banks of the river Medlock. No rockets of any consequence were fired, but the sequal was that four of the members concerned were served with summonses for alledged "contraventions of the Explosives Act of 1875, and an Order in Council of 30th April, 1894."

During the case many things were discussed including apparently the constituents of plum pudding, but the summonses were withdrawn after the Society had given an undertaking not to use explosives in future. The Home Office emphasised that it did not wish to prevent experiments, but could only permit rockets to be fired *after* evidence had been submitted that they were safe and reliable.

One fears that if British youngsters try and emulate their U.S. counterparts, Authority, far from giving encouragement, would, like the Queen in *Alice through the Looking Glass*, proclaim "Off with their heads."

D.B.R.—Destroy Before Reading

The U.S. is notorious for the way news is "leaked" to the press in an attempt to force official comment on secret projects.

Readers of the well-established *Electronic News* were, therefore, not too surprised when the gossip column of a recent issue reported that the Pentagon was "becoming heavily committed" to a radically new weapons system. The report continued: "The M.O.L.E. (Molecular Orbiting Low-Level Explorer) should put an end to war."

Later "leaks" reported, first, that a special new agency S.E.A. (Subterranean Exploration Agency) had been set up to handle the new weapon and, secondly, that the prime contract had been awarded to Accuracy Inc., Massachusetts. Later reports leaked that Accuracy had reached the stage of letting sub-contracts for the M.O.L.E.'s propulsion system—basically an atomic engine "energized by the molecular disintegration of whatever element it traverses," and for the molizing system, a special reverse cone which "pulls the dirt in after the missile so that its path cannot be tracked from the air."

On 4 August last, the first M.O.L.E. was fired from its sinking site in Death Valley. It went into orbit successfully, at depths variously reported as from a few inches to 60,000 ft.

Two weeks later, a senatorial committee clamped the ultra megasecret classification D.B.R. (Destroy Before Reading) on the project, to prevent any further unofficial leaks.

But the news was spreading. Accuracy Inc. began to be contacted by firms eager to get in on the project. One company of concrete specialists implored that it be hired to build the launching pad, or sinking site. Others rang up and before Accuracy could explain, would get right into their sales pitch.

What was Accuracy trying to explain? That the whole thing was a hoax—the brain child of their marketing consultant. Accuracy is a small firm specializing in precision potentiometers. Since most of their products are used in highly classified projects, money spent on ordinary advertising was largely wasted, as a handful of procurement officers in the Pentagon and half a dozen missile firms are their only customers. To spread the name of Accuracy through the industry, the market consultant thought up the elaborate M.O.L.E. "project".

Nobody was more surprised than he when people began to believe his fantastic story. The objective of making the name of Accuracy known has obviously succeeded well.

A secondary objective of the hoax was "to lampoon the engineers". I don't think anybody can be more pompous than the engineers who are saving mankind.

This objective was also well attained?

Pertinent Query—No. 1

Many readers will have seen the fine production on rockets and satellites titled *Breakthrough* televised by the B.B.C. last November. It was good to hear that some of the orbit measurements made by Farnborough were more accurate than those taken by the launchers of the satellites. But, was it not strange that a programme, which was obviously doing its best to boost the small part Britain is playing in astronautics, should finish without once mentioning the British Interplanetary Society?

Towards the end of the programme, the narrator warned that as Man reached out into space, sociological problems would be created on the Earth. The B.I.S. has, of course, been discussing these very problems for the last 25 years!

Pertinent Query—No. 2

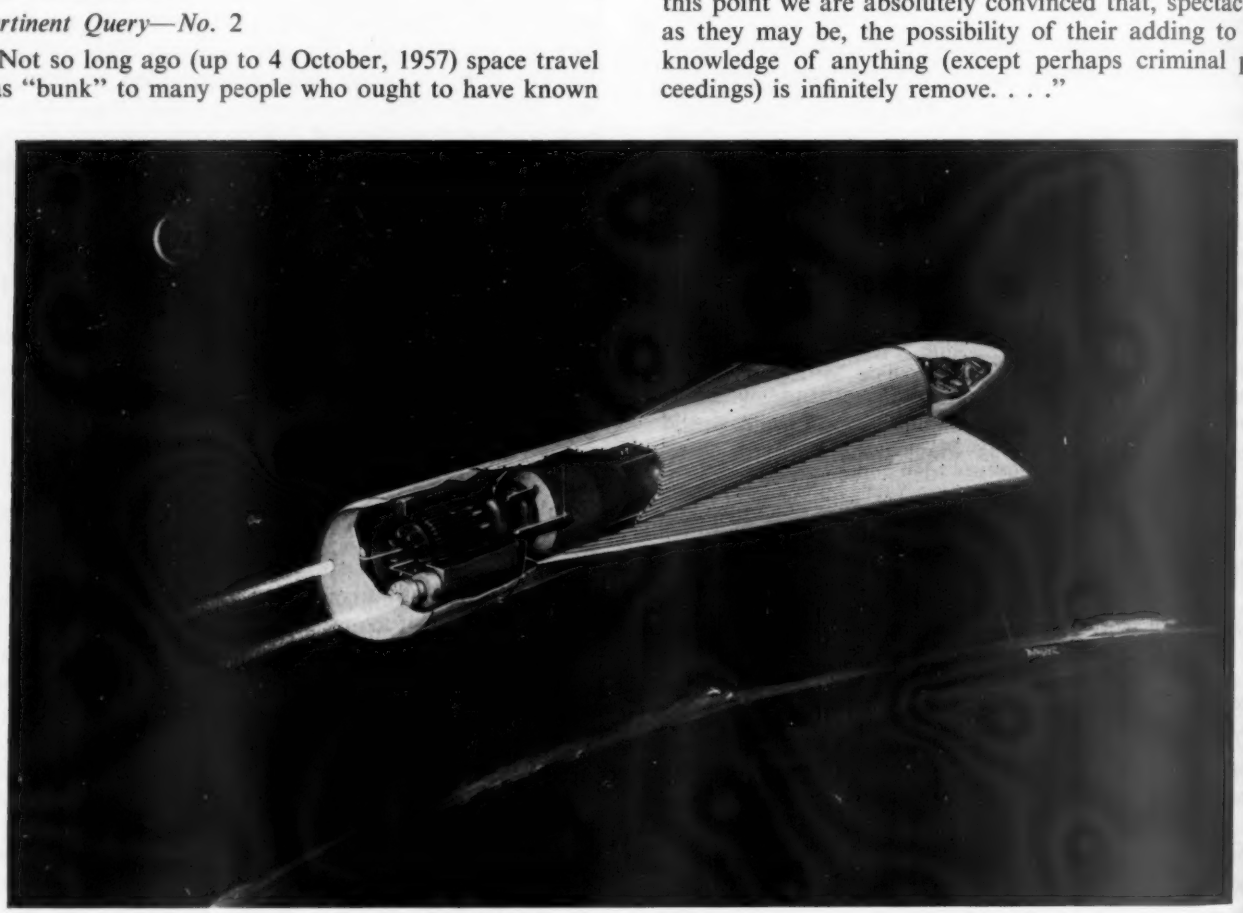
Not so long ago (up to 4 October, 1957) space travel was "bunk" to many people who ought to have known better, and its protagonists a lot of "cranks". But, when both Russia and America *proved* this nonsense, and the Government wanted advice on the subject, to whom did they turn? Not to the B.I.S. which has been seriously considering the technical problems involved and seriously visualizing the possibilities for 25 years. Why?

Food for Thought

In *Breakthrough* a demonstration was made of the release, by remote control, of two nose cone covers of the type used to protect satellites during the ascent through the atmosphere. On the second of these there was a "technical hitch" and the cone remained intact. It was probably a simple fault—possibly a broken connection. In the circumstances the failure did not mean much—but under other circumstances the same simple fault could have ruined a multi-million pound satellite project.

Talepiece

B.I.S. Bulletin, No. 3, Vol. 3, March, 1939, extract: ". . . The next item on our programme will be rocket tests. NOT, you will observe, FREE rocket tests, for on this point we are absolutely convinced that, spectacular as they may be, the possibility of their adding to our knowledge of anything (except perhaps criminal proceedings) is infinitely remove. . . ."



Ion Rocket Vehicle. Of all the suggested methods of powering tomorrow's spaceships, the ion-drive seems one of the most promising. Small experimental motors have already been bench tested with a fair degree of success. In these motors ionized particles, rather than gas as in conventional rockets, provide the propulsive force. In this Rocketdyne artist's concept of an ion rocket a nuclear reactor generates the electrical power. The wing-shaped attachments are radiators to dissipate excess heat

The Rotational Period and Tilt of the Planet Venus

By F. C. WYKES

Very little is known about the planet Venus. In this article, one of the B.A.A. observers gives a summary of our present information—or lack of it!—concerning the length of its "day".

The title of this article refers to two of the most important gaps in our knowledge of the planet Venus, which, up till now, have proved to be controversial topics as a result of their apparent insolubility.

In the past, four[1] groups of values have been assigned to the time it takes for Venus to make one complete revolution on its own axis, as distinct from its orbital period about the Sun of 225 days.

The first group refers to a value, equal to this orbital period, and was originally put forward by the Italian astronomer Schiaparelli[2] in 1877. This meant that one-half of the planet was in perpetual darkness whilst the other half was for ever scorched by the heat from the Sun. There have since been twelve other recorded estimates with this period, and, except for Slipher's questionable spectroscopic observation in 1903,[3] all of them were derived from visual observations of the planet; the latest of these was made by Danjon[4] in 1943. The chief objections to this are that none of the vague markings on Venus appear fixed; and temperature measurements of the night side of the planet, made at Mt. Wilson with the 100-in. telescope, suggest that there is no evidence for the extremely low temperatures that would exist on that part of the planet, if it were in perpetual darkness.

The second group gives a value for the rate of axial spin of one revolution in a few weeks. Ross,[5] at Mt. Wilson, derived a value of 30 days in 1927, from photographic evidence; and observations of a similar nature, carried out by Kuiper in 1954, also in America, again suggest a period of a few weeks at the most.[6] In between these Martz,[7] in 1933, and Roth,[8] in 1953, obtained estimates of 37 days and 15 days, respectively, by visual methods.

Other observers have suggested that the period is of the duration of a few days only. Pickering, in 1921, and McEwen, in 1924, both obtained an estimate of 68 hours, again, by visual observations of vague shadings on the planet.[9] An interesting series of observations by Dr. Steavenson in 1924 gave a value of 8 days for the rotational period, which differed in the method of deduction from previous estimates, by assigning a very large angle of tilt to the planet, which had been assumed until then to have a small tilt, more like that of the Earth. This would mean that each pole in turn would move across the centre of the disk from limb to limb, alternately, during each Venus year, as seen from the Earth. However, in 1956 radio emission from Venus was detected by Dr. Kraus[10] in America, which showed regular periodic occurrence, with maxima of intensity lasting for a few hours at a time.[11] Since this radio emission could only be received on Earth, if the source of the radio waves is near the centre of the visible disk of Venus, there would be no periodicity when one of the poles is in a co-incident position, which would be the case if Venus exhibits a very large angle of tilt. In fact, there has been apparently no continuous radio noise for more than a few hours at a time. Undoubtedly, the regular frequency of occurrence of the radio noise is connected with the rotation period of Venus, but more than likely by an indirect relationship. At present there is insufficient evidence to elucidate this.

The remaining estimates of the rotation period all refer to a value of approximately 24 hours, similar to our Earth's. There have been many adherents to this idea from the seventeenth century up to the present time. However, such a period would be accompanied by flattening at the poles sufficient to be measured by optical means. (It is a well-known fact that the Earth's equatorial bulge, which amounts to the same thing as flattening at the poles, is quite appreciable and is due to the speed of the Earth's rotation.) So far, no such observations have been recorded and the flattening is thus inappreciable on Venus. Secondly, an axial spin as quick as one revolution in 24 hours could be detected by spectroscopic means, using the principle of the Doppler shift. Briefly, this would mean that the quality of the reflected sunlight from Venus, analyzed at the preceding limb, should be slightly redder than that observed at the following limb, sufficient for the slight difference in position of fixed solar emission and absorption lines in the spectrum, to be resolved in the spectroscope, if the rotation period of Venus is quicker than about 48 hours for each revolution. So far there has been no confirmation of this nature to support the 24 hour period.

Thus there is still considerable uncertainty in the length of day on Venus, although on theoretical grounds, with particular reference to the angular momentum of the planet, the suggested period of a few weeks seems the most likely.

The tilt of Venus' polar axis is in the same stage of uncertainty as her rotation period. Less attention seems to have been paid to this problem in the past, although

reliable estimates of the length of the day on the planet cannot be made without an adequate knowledge of its value. A great deal of weight has been given, valid or otherwise, to a small value for the angle of tilt, which is a very unscientific state of affairs, considering the lack of data in the past.

One of the first recorded estimates was made by Pickering, who gave a value of 85° as the angle of tilt. However, in an article published in 1917,[12] he pointed out that, given enough time in the order of hundreds of millions of years, the axes of revolution of the planets would eventually come to lie in a position perpendicular to their orbit planes. This will be due to the tidal action of the Sun. As mentioned before, McEwen and Steavenson also adhered to the idea of a large angle of tilt. The most recent estimate was made by Kuiper in 1954, who examined the direction of drift of the vague shadings photographically at intervals in violet light.[13] The value he gives is 32°, approximately, though this still allows for some degree of uncertainty.

At any rate, it seems fairly well established that the angle of tilt is not large and is more comparable with the terrestrial and Martian values of 23½° and 25°, respectively.

At present, work is in progress on this problem among members of the Mercury and Venus section of the British Astronomical Association; but it is too early to announce any clear-cut results; and far more numerous and extended observations are required.

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Other points made by the South African Society are that the radar stations of the South African Defence Department might play a useful rôle in the tracking of satellites and carrier rockets; that the South African Naval Base at Simons Town, near Cape Town, could cover the sea between the Cape and the Antarctic for tracking purposes and, possibly, the recovery of satellite launching vehicles. The Marion Islands, Tristan da Cunha (where the only two permanent weather stations are located south of the Cape) and Pouvet Island could be usefully employed as future observation and tracking bases.

Rocketry in India

News of rocket activity in India have recently been received from the Indian Astronautical Society. In collaboration with the Indian Defence Department, the Society is presently engaged in developing solic propellant rockets of high specific impulse. A two-stage test rocket reached a height of over 50,000 ft. on 3 November, 1958. Separation was achieved by four small rockets placed between the first and second stages. Burning time of the two stages was 28 sec., and a special device placed in the nose cone released a magnesium flare at the peak altitude.

The Society is now working on a large four-stage rocket (40 ft. long and 14 in. maximum diameter) designed on the lines of America's Farside. Present plans are that the rocket will be lifted to 40,000 to 50,000 ft. beneath three or four plastic balloons and then fired by a radio signal transmitted from the ground.

The final stage will carry instruments weighing 10 lb. A lightweight transmitter, developed by the Society in collaboration with an electronics firm, will transmit data on a frequency of 205 megacycles; it weighs only 5 oz.

Mr. S. K. Kumar, Joint-Secretary of the Indian group, has stressed that this project can only be realized through the co-operation of the Indian Defence Department. However, the scheme has apparently aroused a great deal of interest, and Mr. Kumar believes that by the time the Commonwealth Symposium opens in August, they will be able to show tangible progress.

Other projects in which the Society is involved are a guidance system for an air-to-air missile, and a liquid propellant motor of 1500 lb. thrust.

Whether or not India will ultimately have her own modest rocket and missile industry depends on many factors, but the siting of stations there for satellite tracking would certainly give the country importance in the prospective Commonwealth Programme. It might even be possible for India to have a radar station, which might not be too expensive if 30 ft. "dishes" were used.

These, then, are a few of the ideas which are being examined by the organizations forming the nucleus of the Commonwealth Astronautical Committee. In future issues of *Spaceflight*, it is planned to include reports from other parts of the Commonwealth, and to survey relevant fields of industry both at home and abroad.